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## A PNEUMATIC EXCAVATOR.

DURING the construction of the Tay Bridge considerable difficulty was experienced in sinking the cylinders for the piers, several expedients having been successively tried and abandoned. At length Mr. Reeves, one of the engineers engaged on that great work, succeeded in devising an excavator on the pneumatic principle, by means of which the sand was sucked up from within the cylinders and discharged into hoppers, the cylinders following down the displacement of the sand. One of these excavators, or sand pumps, as they are also called, has just been completed by Messrs. A. Wilson & Co., of the Vauxhall Iron Works, Wandsworth Road, and has been inspected at work on their premises by a number of engineers and other gentlemen interested in such matters during the present week. The excavator has been made for the New South Wales Government, and it will be sent out to Sydney, where it will be used in sinking cylinders in connection with the improvements now in progress in the harbor there. The apparatus consists of a pair of cast iron cylinders 4 feet in diameter, carried on a staging and placed in connection at their tops with an air pump, driven by a small steam engine. The connections are so arranged that the air can be exhausted either from one cylinder singly or both at the same time. The bottoms of the cylinders are connected with a suction tube 3½ inches in diameter, which leads down to the sand. Here again it is so arranged that the cylinders can be worked either singly or in combination by means of self-acting valves. The soil is discharged from each cylinder by a trap-door placed in its front. The engine and air pump are carried on the same framing, and the whole forms a very compact arrangement. In operation, the engine being started, the air is exhausted from one cylinder; the sand and soil rushing up into the vacuum thus created soon fill the cylinder, the fact being indicated by a tell-tale. The connection is then made between the air pump and the second cylinder, and that is similarly filled, during which time the contents of the first cylinder are discharged, and it is ready for the air pump by the time the second cylinder is full, and so the process continues alternately until the desired end has been attained. The excavator worked very successfully; a vacuum of 24 inches was maintained during exhaustion, and the cylinders were rapidly filled with sand and water from a pit, the contents being quickly discharged. Besides the Tay Bridge, this excavator has been advantageously used at the Dundee Esplanade, where a considerable quantity of land was reclaimed by its aid. It also succeeded in pumping the sand from a wreck at Fraserburgh, which led to the recovery of the vessel. In fact, the pneumatic excavator appears to have a wide field of practical application before it.

## ENGLISH RAILWAY ACCIDENTS.

DURING the first quarter of this year the number of persons killed and injured on railways in the United Kingdom in the course of public traffic was—killed, 219; and injured, 714. By other accidents on railway premises eleven persons were killed and 481 injured, These accidents are classed under various heads: Ninety-eight passengers and twenty-eight railway servants were injured by accident to trains, rolling stock, permanent way, etc.; twenty passengers and 105 servants were killed, and 114 passengers and 433 servants were injured from other causes. Sixteen persons were killed and eight injured while passing over railways at level crossings; and the number of accidents to trespassers, including suicides, was seventy-four killed and twenty wounded. During the three months there were reported eight collisions between passenger trains or parts of passenger trains, by which eighteen passengers and one servant were injured; twenty-three collisions between passenger trains and goods or mineral trains, engines, etc., by which sixty-nine passengers and thirteen servants were injured; ten collisions between goods trains or parts of goods trains, by which twelve servants were injured; twenty-two cases of passenger trains or parts of passenger trains leaving the rails, by which four passengers were injured; two cases of trains running into stations or sidings at too high a speed, by which five passengers were injured; 327 failures of tires, one servant being injured; ninety-eight failures of axles, two passengers being injured; and 1,187 broken rails.

## SIMON'S GAS AND STEAM MOTOR.

WE present, herewith, representations of the model of Simon's Gas and Steam Motor, which obtained a silver medal at the Paris Exhibition, and also a view of a new type of the motor now in course of construction.

The Simon Motor is actuated by the combined forces of air, compressed gas, and steam, and without the aid of a boiler and its accompanying fire to generate the steam. The air and gas are aspirated and compressed in a cylinder, where they are intimately mixed, and from which they pass into the motor cylinder, above a jet kept constantly burning; they then burst into flame and burn without explosion. The gases, on becoming heated, increase in volume and act upon the piston. The heat that they contain, on escaping from the cylinder, is utilized in the production of steam in a generator of special form. This steam, admitted into the motor cylinder at the same time as the mixture of the air and gas, considerably increases in expansive power, and serves at the same time to lubricate the sides of the cylinder. By this process there is obtained the useful maximum effect of the gas, and the consumption is less per horse power than in other motors. The addition of the steam possesses, moreover, the advantage of preventing a soiling of the working parts. The consumption of oil is no greater than takes place in ordinary steam engines. The Simon Motor makes no noise, and works as silently as a steam machine. Every stroke of the piston acting in a useful manner, there is no need of the driving wheel being of very great size. The machine requires no foundation; its weight is relatively light, and the small space that it takes up permits of its being located almost anywhere in a building. A one-horse power motor is about 8 ft. long by 3 ft. wide; and a two-horse power occupies a space of about 8½ ft. by 3 ft.

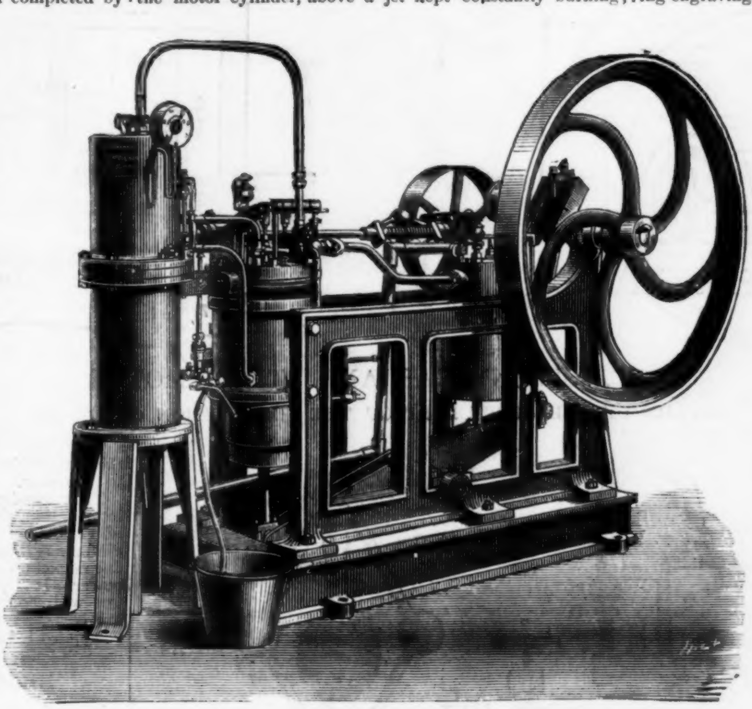


FIG. 1.—SIMON'S GAS AND STEAM MOTOR.

(As shown at the Paris Exhibition).

In the two machines, as will be seen from the accompanying engravings, the cylinder for compressing the gases and the motor cylinder are placed each at one of the extremities of the frame, and are each connected with the opposite ends of a walking-beam situated beneath. At the extremity of the lever, and at the side of the compression cylinder, is attached the crank which actuates the driving shaft. In the machine shown at the Exhibition, the steam generator is placed at the side of the motor cylinder and outside of the frame, but in the new model it is situated in the center between the two cylinders.

On this last model have been built 1, 2, and 4 horse power motors, the price of which, with accessories, is respectively $460, $600, and $800.

For motors above four-horse power, M. Simon has invented another arrangement in which the connecting-rod, fastened to the piston of the motor cylinder, acts directly on a crank-shaft. We give on next page a transverse section of this arrangement, with views of details, by means of which we will explain the working of this interesting machine. In the transverse section (Fig. 4), A is the compression cylinder, in which moves the piston, B, connected by the rod, C, with the driving shaft, G. At the extremity of this shaft is borne a bevel-wheel, Y, acting by means of another like wheel on the rod, X, of the governor. As soon as the velocity increases, the balls of the governor fly apart and act on the cam, D, which regulates the admission of the air and gas into the cylinder. The quantity of air and gas admitted into the compression cylinder being lessened, the speed of the machine is diminished, and the cam returns to its first position. The slide is kept in contact with the cam, D, by means of a spring, which serves to effect its return movement.

The air is led through the tube, F, and the gas through K; they enter the box, L, pass through the opening, M, and enter the cylinder, A, during the descent of the piston. While the piston is ascending the air and gas are compressed and driven in part through the passage, R, into the motor cylinder, and in part into the reservoir, Q, thus feeding the permanent interior flame at *o*. N is a counter pressure valve which may be closed by means of the hand wheel, P. By closing this valve the compressed mixture is prevented from entering the pipe, R, and the machine is stopped. At the extremity of the passage, R, is a slide, S, moved by an eccentric, and which regulates the admission of the compressed gases to the motor cylinder. The gases traverse a metallic mesh, T, and become lighted by contact with the flame, *o*; and the latter is fed by the mixture of air and gas coming from the reservoir, Q. The gases on becoming lighted, dilate and cause the piston, *b*, to descend. On leaving the cylinder, through the pipe, *d*, the gases meet the slide, *e*, actuated by an eccentric borne on the driving shaft; they enter the steam generator, *h*, which is filled with water to a certain height, traverse a series of conduits, and escape (after parting with nearly the whole of the heat they possessed) through an orifice communicating with the chambers in which they had circulated. The water in the generator, *h*, communicates with that which circulates in the jacket, *k*, of the cylinder, W, and also with that which fills the jacket, *l*, of the cylinder, A. The water is first warmed by the sides of the motor cylinder in which takes place the expansion of the lighted gases, and afterwards by the gases which escape from this cylinder; and the steam produced is collected in the upper portion of the generator. This steam is led towards the opening, V, of the slide, S, and, by means of a conduit, reaches *r*, where it becomes mixed with the lighted gases. The tube which admits the steam may be closed by the hand-wheel, P.

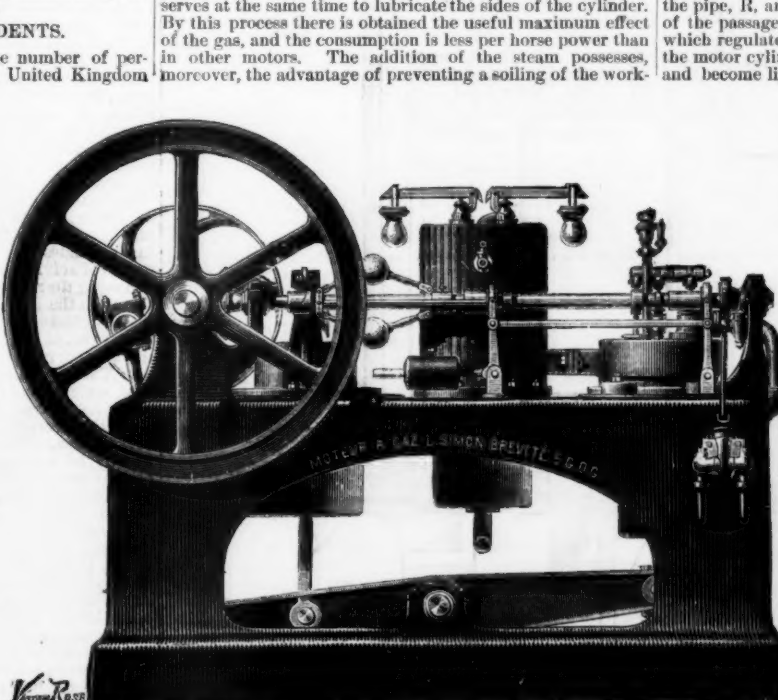
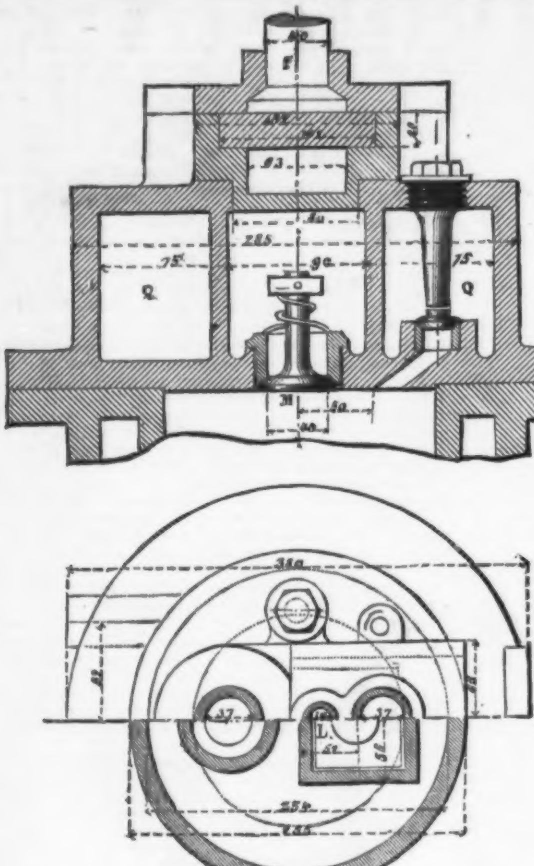
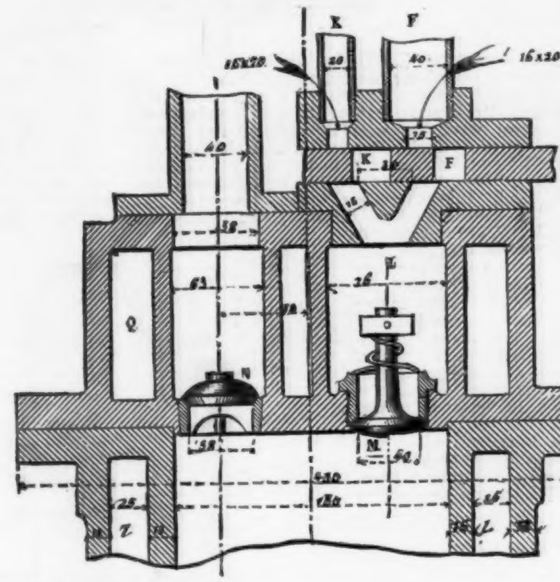



FIG. 2.—NEW MODEL OF SIMON'S GAS AND STEAM MOTOR.

The water from the generator is led into the jacket of the compression cylinder, the heating of which it prevents by absorbing some of the heat; it then passes into the jacket of the motor cylinder, where it continues to gain heat by cooling the sides of this





cylinder, and finally it reaches the generator, *h*, where the steam is produced by the aid of the escaped gases. Every portion of the heat produced is thus utilized. The drawings in detail (Fig. 3), given herewith, show two transverse sections, and a plan of the upper part of the compression cylinder; and from these may be more readily seen the arrangement that has been devised for the passage of the gases and compressed air into the conduit, R, and the reservoir, Q.

To put the machine in motion a few turns are given to the hand-wheel in order to compress the air and gas in the cylinder, A; a part of this mixture passes into the reservoir, Q. A small stopper is then opened to allow the gas to be lighted at *o;* the compressed gases are immediately inflamed, and, as a consequence of their expansion, cause the piston, *b*, to move. While the descending motion of this piston is taking place, an ascending movement is being effected in the compression cylinder, and a regular movement is given to the motor.

FIG. 3.—SIMON'S GAS AND STEAM MOTOR.

DETAILS OF THE UPPER PART OF THE COMPRESSION CYLINDER.

The necessity of moving a hand-wheel to set the machine in operation, presented some difficulties at first, in motors of more than four-horse power. To overcome these, M. Simon has invented a special arrangement which will allow one person unaided to start a machine of even eight-horse power. It is probable, then, that these higher power motors will soon be adopted largely by manufacturers, inasmuch as the range of industrial purposes to which they may be applied is very extensive.

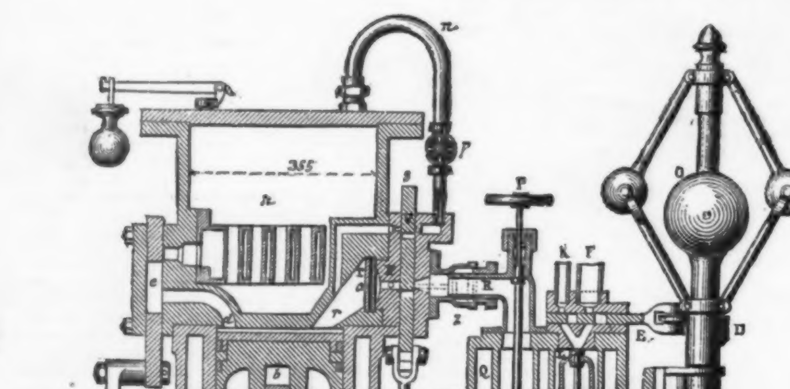


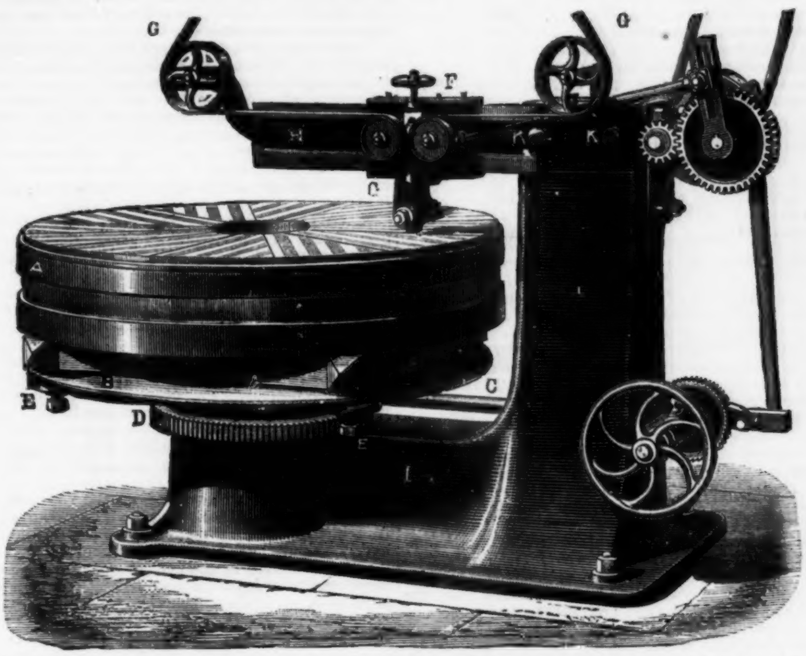
FIG. 4.—SIMON'S GAS AND STEAM MOTOR (Transverse Section)

## MILLSTONE DRESSING MACHINES.

THE scientific development of flour manufacture which is now in progress necessitates the use of a higher class of instruments used in the process of manufacture than those employed when the art was in a more primitive condition. At one time a pestle and mortar were sufficient machinery for making the flour of which the bread of peoples was made, but it is characteristic of the human race that they never know when to "let well alone," and hence they have advanced by gradual stages from the simple to the complex in the appliances used in the practice of all the arts which contribute not merely to the supply of our wants, but our luxuries. The old-fashioned miller with his old-fashioned tools produced a good sack of flour, which the old-fashioned baker could convert into good bread; but the old-fashioned miller and his tools are alike obsolete. If millstones are destined to share the doom that has been pronounced upon them with such emphasis, the mill will, as a matter of course, disappear, its occupation, like Othello's, having gone; but there is reason to believe that these time-honored means of manufacturing flour will exist for some considerable time longer. Millstones are capable of performing important work, even in connection with the advanced system of scientific milling; but in the dressing of their grinding surfaces it is often a question whether the means used, when automatically adapted to the work, are not productive of better results than when the work is accomplished manually, and in the different more or less automatic dressing machines that have been introduced the trade has the means of solving that question.

Among the milling exhibits noticed in the *Miller* in connection with the Paris International Exhibition of last year was the diamond millstone dressing machine of Messrs. Roger, Son & Co., of Le Ferté sous Jouarre, France. To-day we notice another machine of the same class, viz., that of MM. Dupety, Theurey Geuvin, Bouchon & Co., of the same place. This firm, which dates from 1752, has extensive millstone works, and it has gained many high-class awards for its workmanship at the various international exhibitions where they have been shown. The machine of Messrs. Roger, Son & Co., it may be remembered, was used for dressing the joints of bars used in the manufacture of millstones, as well as for facing the latter. The Dupety machine, which is shown on next page, is used chiefly on the face of the stone. The millstone to be dressed, A, is placed upon a revolving platform. B, actuated by a shaft, C, connected with a cog-wheel, D, the stone being adjusted to a true level by means of regulating screws, E E, the weight of the stone being sufficient to keep it firmly fixed in its place during the operation of dressing. The machine being set in motion, the diamond carriage, F (the diamonds of which are actuated by the straps, G G G), starting at the circumference of the stone, travels toward its center, the diamond cutter making 600 revolutions per minute; and by a reverse motion of the shaft, the platform on which the stone rests is turned gently, the cutter traveling from the center to the circumference, the face of the stone being subjected to the cutting action of the diamond until it is completely dressed.

The cutting pitch of the diamond is regulated by an inclined slide, H, fixed to the cast-iron framework of the machine, I I, by the bolts, K K. The incline of the slide is in the direction of the center of the stone, which secures uniformity in the cutting, and the inclination is regulated by means of adjustable wedges, an arrangement which secures mathematical exactness in the depth of the cut. The action of the machine is similar to that of a plane, and, as we have seen, the course of the diamond is from the circumference to the center, and *vice versa*, the face produced on the millstone by means of the machine being partially granulated, which is claimed as an advantage. In comparison with that of the carriage the movement of the platform which carries the stone is very slow, and as the chief part of the work is performed by mechanism which requires but a small driving power, the cost of the latter is proportionally small.—*The Miller.*

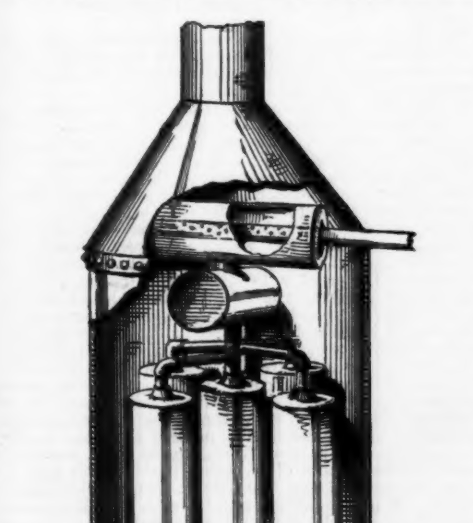



THE DUPETY DIAMOND MILLSTONE DRESSING MACHINE.

## A STEAM SHARPIE YACHT.

By H. K. STROUD.

I HEREWITH send you dimensions of the steam sharpie Manuelita, which I have built and used for over a year past: Length over all, 16 feet 5 inches; beam, 4 feet 6 inches. Can make six miles per hour on dead water. Engine, 2 inches diameter of cylinder by 4 inches stroke; weight of engine, 18 lb.; engine vertical, link motion; pump, ⅜ inch diameter of plunger; 4 inch stroke; worked from arm on crosshead; pins and rods of engine of steel.



BOILER OF STEAM SHARPIE YACHT.

Propeller wheel, 16 inches diameter, 2 blades; blades are screwed to hub, can be varied in pitch from 16 inches to 26 inches. The boiler, which is shown in the engraving, is sectional and peculiar, composed of seven mercury flasks connected by ¾ inch nipples. Five flasks hold water and generate steam. The five are coupled near the bottom by close nipples for water circulation. From the flasks rise nipples, 5 inches long, ¾ inch diameter. These are united in one outlet, which screws into another flask laid horizontally above the vertical five. That is surmounted by another flask, also laid horizontally, but across the lower one, a close nipple connecting the two. A dry pipe is made by running a piece of ¾ pipe nearly the whole length of the upper flask or superheater, which pipe is perforated with small holes to cause a uniform draught of steam, instead of drawing from one spot. The casing which surrounds the whole is 16 inches diameter, and, including the fire box and uptake, is nearly 4 feet in height. The space between grate and boiler (8 inches) is laid up with a circle of fire brick. A second casing of sheet iron or Russian iron, leaving an air space, would be an improvement.

Propeller shaft, ¾ inch diameter, steel. A piece of ¾ inch pipe 2 feet long forms the sleeve and journal for the shaft to run in. Both ends are threaded, and a plate is screwed on at the after end, which is fastened on the stern post. On the forward end is formed a stuffing box, by screwing on a reducing socket 1 inch by ¾, and fitting a gland to it. The thrust is on the plate at the after end of sleeve. The shaft fits the sleeve only at the ends, being turned a little smaller through the middle.

[Continued from SUPPLEMENT No. 177.]

## USE OF COMPRESSED AIR MOTORS FOR STREET CARS.

Report to the Pneumatic Tramway Engine Co., of New York, by General H. HAUPT, C.E.

### OBJECTIONS.

I HAVE been shown a criticism of the motor made by a mechanical engineer of some prominence, which surprises me greatly, and can only be accounted for on the supposition that the letter which recites the objections was written without consideration.

I am thankful, however, to have objections stated; when they can be shown to be groundless, they serve to inspire and increase confidence.

The objections were:

1. The air car requires 50 horse power to keep it in operation.

True; but if dry air be used, the same engine will charge 7 cars per hour, and if moist and heated air be used, 14 cars, if the run should not be increased and only half the air should be required, which is only 4 horse power to a car, and each horse power costs in coal consumed one-fourth to one-third as much as in a street motor.

Second Objection. The cost of repairs for the steam cars would be less than for the air car.

Answer. No reasons are given, and the fallacy of the assertion is self-evident. There is no fire box to burn out, and no boiler to rust, burn out, or explode. The reservoirs, filled with air absolutely dry, are as nearly imperishable as anything on this mundane sphere can be. The parts liable to wear by friction are the same as on other engines, neither more nor less expensive to repair, but the heaviest expenses of fire box, boilers, and flues are all saved.

Third Objection. The air car is not so reliable as a steam car, as it has not the same surplus for emergencies.

Answer. Why not? A surplus is provided of 33 per cent. Does a locomotive finish its trip with as much reserve power in coal and water in its tender? Besides, all the cars of a train can have air cylinders under the seat, the whole of which can be held in reserve.

The above are the only objections that I have heard advanced. If there is any force in them I cannot perceive it.

### THE MORAL AND SANITARY INFLUENCES OF THE PNEUMATIC MOTOR.

A claim that the pneumatic motor can improve the morals and promote the health of a great city may provoke a smile, but incredulity may yield to conviction under the logic of facts.

Quite recently a prominent citizen of New York, noted for his efforts in the interests of humanity, invited a number of the clergymen of that city to meet at his house to consider the terrible and increasing evils of the tenement house system, and devise, if possible, some plan for its amelioration, and it was decided that all who were present should, on a day agreed upon, preach a sermon on the subject.

The following startling statistics were given:

In a population of one million inhabitants in New York, one-half, or 500,000, live in tenement houses, sometimes four families in a room, the boundaries defined by chalk lines. The Seventeenth Ward averages 305 inhabitants to the acre. The Eleventh Ward, 356 to the acre, and some blocks 750 to the acre. The deaths last year were 27,000, which is 25 per cent. more in proportion to population than in Philadelphia, where separate houses are occupied by separate families, and the tenement house system does not exist.

The average of cases of sickness to one death is 28, or 750,000 cases of sickness of some kind in New York annually. Of the deaths, 70 per cent. occurred in the tenement houses, leaving 30 per cent. for the balance of the population of equal number.

The deaths in tenement houses were, therefore, 133 per cent. greater than in the balance of the population. These houses furnish nearly all the paupers, and criminals, and a majority of the voters. Their occupants hold the balance of power, control the elections, elect city officials, and impose taxes on property owners, while contributing nothing themselves to the burdens they impose on others. These tenement houses are the very sinks of iniquity, hotbeds of vice and immorality, the abodes of impurity, and the birthplaces of pestilence. What is the remedy for these terrible evils? The answer is, separate households and suburban dwellings. Give this population, and others similarly situated, pure air, green fields, and heaven's sunshine, and the evils will be greatly mitigated, if not radically cured.

How is this to be obtained? How can laboring men, living three to ten miles from a city, get to their work and return to their homes at an expenditure of time and money within their moderate resources? The answer is, cheap and rapid transit. A motor whose speed is limited only by considerations of safety, and whose cost for power will not exceed one-third of the cost of steam, is the best solution of this most difficult problem. The key to this solution is the pneumatic motor.

Respectfully submitted.

H. HAUPT, Consulting Engineer.

### ESTIMATE OF THE COST OF POWER BY THE USE OF THE PNEUMATIC MOTOR AS COMPARED WITH HORSES.

From the reports of sixteen horse car companies in the city of New York, operating 102 miles of road with 1,297 cars and 10,301 horses, it appears that the expenses for 1876 were:

| | | |
|---|---|---|
| For repairs of harness | $41,861 | per horse $4.06 |
| " shoeing horses | 234,578 | " 22.77 |
| " feed | 1,281,316 | " 124.39 |
| " stable expenses | 434,014 | " 42.13 |
| " replacing horses | 227,694 | " 22.10 |
| | $2,219,463 | $215.45 |

Cost of one horse one month, $18.00; number of horses to one car, average 8.

*From the Report of the Second Avenue Railroad Company for* 1878:

Number of cars, 167; number of horses, 1,197; cost of cars, $92,800; average cost of one car, $556.00.*

EXPENSES OF RUNNING.

| | |
|---|---|
| Repairs of cars and harness | $30,319 |
| Horse shoeing | 16,593 |
| Horses | 42,000 |
| Stable expenses | 46,542 |
| Feed | 108,785 |
| | $244,239 |

| | |
|---|---|
| Average expenses per horse | $204 |
| One horse, one month | 17 |
| Average horses per car | 10 |

ADDITIONAL ITEMS.

The cost of horses, harness, wagons, etc., was $116,600, the interest and depreciation of which will be taken at 15 per cent., in addition to horses replaced = $17,490. 167 cars cost $92,000, the repairs on which have been included, but an allowance must be made for interest and depreciation not covered by repairs, say 10 per cent., making $9,200.

| | |
|---|---|
| Pay of conductors and drivers | $167,335 |
| The total expenses of all kinds were | $730,466 |
| The total number of passengers carried | 16,062,560 |
| The cost per passenger | 4·55 cents. |
| Which includes a six per cent. dividend of | $72,000 |
| Cost per passenger, exclusive of dividend | 4·10 cents. |

SUMMARY.

| | |
|---|---|
| Expenses as above | $244,239 |
| Interest and depreciation in horses, etc. | 17,490 |
| " " cars, " | 9,200 |
| Conductors and drivers | 167,335 |
| Interest on stable property | 24,150 |
| Total running expenses with horse power | $462,414 |
| Running expenses per passenger, exclusive of dividends and general expenses | 2·88 cts. |
| Including general expenses | 4·10 " |
| Including dividends as above | 4·55 " |

### COST OF OPERATING THE SECOND AVENUE RAILROAD WITH PNEUMATIC MOTORS.

It will be assumed, as the basis for this comparative estimate, that short motors will be used, each motor carrying two cars, and making trips in two-thirds of the time required with horses. The expense of conductors and drivers, which amounts to $1,000 per car, will be reduced one-half.

The motors required for 167 cars† will be 84, at a cost of $1,500 each, $126,000. The interest, repairs, and depreciation, 20 per cent. = $25,000.

If the distance between termini be taken at 8 miles, and the time one hour, the intervals between trains will be under 1⅓ minute, and the cost of compressor plant will be estimated for each station at $20,000. Interest and repairs on which, 20 per cent., $4,000.

It has been shown that the compressor at the Harlem station, which develops 66 horse power while working, charges a motor in 7 minutes, or at the rate of 9 per hour, and at the same rate the power required to charge one motor in 1⅓ minute would be 380 pounds, and at 8 pounds of coal per

* It is stated by officers of the company that the cars reported (167) include many not in regular use; the actual number in use is about 106. Horses to one car = 10. Cost of car when new, $1,080.

† If, as is now stated, the actual number of cars is 106, instead of 167, the motors required will be 53 instead of 84, and motor expences will be reduced 25 per cent. This will reduce the cost per passenger on sixteen millions carried to 0·67 cent for motive power expenses, as against 2·88 cents with horse power.

horse power per hour, the consumption for average of 16 hours would be 1,140 pounds per hour, and 18,240 pounds, or 9·12 tons, per day.

The Delamater and Corliss works both claim a duty of 2¼ pounds of coal per horse power on the engines constructed by them, but in this estimate 3 pounds have been allowed, and manufacturers have proposed to furnish engines and compressors capable of charging one car per minute, for $20,000. The present motor runs 10 miles, but with the increased reservoir capacity of motors not carrying passengers, the run should be increased to 13 miles, and one station in the middle should run the road.

To remove all questions, however, as to the sufficiency of the estimate now submitted, two stations will be allowed instead of one, each costing $20,000, and the coal consumption will be increased to 12 tons. The estimate will then stand, as compared with horse power:

| | |
|---|---|
| Interest and repairs on 167 cars, costing $92,000, at 20 per cent. per annum.. | $19,400 |
| Interest and repairs on compressor plant, costing $40,000, at 20 per cent...... | 8,000 |
| Interest on building for compressors..... | 5,000 |
| 84 drivers and conductors, $1,000 per car | 84,000 |
| 4 engineers at $3.00 per day, 4 assistants at 2.00 " 8 firemen at 2.00 " 12 tons coal at 41·00 " } per year, | 27,010 |
| Total motor expenses........ ......... | $143,410 |
| Cost per passenger for running expenses, | 0·89 ct. |
| Other expenses as before, including a six per cent. dividend, $730,046—$462,414 ......... | $267,632 |
| Total expenses, including dividends..... | $411,042 |
| Cost per passenger on 16,000,000, with dividend .......... | 2·57 cts. |
| Cost per passenger, exclusive of dividend | 2·12 " |
| Maximum capacity of 167 cars all seated, and assuming all passengers as through .......... | 20,000,000 |
| The comparison of running expenses above stated, with horse power per passenger .......... | 2·88 cts. |
| With pneumatic motor.......... | 0·89 " |

And a very slight increase in the number of passengers would permit charges to be reduced to 2½ cents, and still pay 6 per cent. dividends.

CONSEQUENCES.

The estimate herewith submitted, which is believed to be full and liberal, would seem to justify conclusions of great practical importance to stockholders of surface roads and to the public generally. The Second Avenue Railroad has been taken as an illustration, only because the data were accessible. The same results would, no doubt, follow a comparative estimate on other roads.

On the basis of sixteen millions of passengers carried on this road, operated by horse power, the actual results were:

| | |
|---|---|
| Running expenses per passenger, inclusive of dividends and general expenses .. | 2·88 cents. |
| Estimate by use of pneumatic motor ..... | 0·89 " |
| Cost per passenger by horse power, including general expenses, but not dividends .......... | 4·10 " |
| Estimate of use of pneumatic motor...... | 2·12 " |
| Cost per passenger by horse power, including both general expenses and dividends.......... | 4·55 " |
| Estimate by use of pneumatic motor...... | 2·57 " |

What is the lesson which is taught by these figures? If, on the basis of the actual business of the Second Avenue Railroad, the economy of operation can be so greatly increased by the use of the pneumatic motor, that dividends can be paid on a charge of 2½ cents per passenger from City Hall to Harlem, a distance of 8 miles, who can calculate the increase from greatly reduced fares coupled with accelerated speed?

The elevated railroads have been a complete success. Horse railroads and stages are doomed; their patronage is rapidly departing, but the compressed air motor comes forward opportunely to save surface roads from ruin, retain their efficiency, usefulness, and dividend earning capacity, utilize existing roads, plant, and employes, and secure a change of system almost without any expenditure of capital, since the sale of horses and harness will generally pay for the motors that supersede them.

If the Second Avenue Railroad Company would put the fare through from City Hall to Harlem at 5 cents, or half the elevated railroad charge, and run the 8 miles with compressed air in 40 minutes, a speed entirely practicable if street obstructions are not too numerous, the bulk of the population would patronize the surface roads; but if these improvements are not adopted, it is too clear to admit of controversy that horse railroads must succumb. A successful competition with elevated railroads is with horse power obviously impossible. Respectfully submitted.

H. Haupt, Consulting Engineer.

SUPPLEMENT.

For several days previous to March 12th, 1879, experiments were made with the motor on the Second Avenue Railroad, the results of which it is proper to note.

March 9th, started from depot at 127th street, and made three round trips, with the following record:

| | |
|---|---|
| 1st trip started with pressure.......... | 360 pounds. |
| Consumed .......... | 95 " |
| Returned with.......... | 265 " |
| 2d trip started with.......... | 265 " |
| Consumed.......... | 95 " |
| Returned with .......... | 170 " |
| 3d trip started with.......... | 170 " |
| Consumed.......... | 75 " |
| Returned with.... .......... | 95 " |

This result was so remarkable, that the president of the company, Mr. F. Henriques, requested the writer to superintend some further experiments, to ascertain if increased duty would be secured by running at reduced pressures. Accordingly, on March 10th, three more trips were made, with the following record:

| | |
|---|---|
| 1st trip started with.......... | 360 pounds. |
| Temperature of water .......... | 324° |
| Mean working pressure while running .......... | 120 pounds. |
| Water absorbed .......... | 31 " |
| Pressure on return.... .......... | 290 " |
| Consumed .......... | 70 " |
| 2d trip started with.......... | 286 " |
| Mean working pressure.......... | 120 " |
| Consumed water.......... | 11·3 " |
| Temperature of water on return.... | 198° |
| Pressure at end of trip .......... | 195 pounds. |
| Consumed.......... | 91 " |
| 3d trip started with. .......... | 195 " |
| Mean working pressure until pressure fell below.......... | 120 " |
| Water absorbed.......... | 19·8 " |
| Temperature on return.......... | 180° |
| Pressure at end of trip... .......... | 95 pounds. |
| Consumed .......... | 100 " |

The comparison of these two tests exhibits very remarkable results.

The total consumption of air in the three round trips was precisely the same, starting with 360 pounds and finishing with 95, consuming 265 pounds, or an average of 88·33 each trip. The last trip of the first series was run with 75 pounds. This fact it is difficult to explain, as the water was certainly much cooler than at the start, and it could not have contributed so large a proportion of vapor.

In the first run of the second series the air consumed was 70 pounds pressure, equivalent to 747 cubic feet, or 57½ pounds at atmospheric tension, and this air absorbed the very extraordinary amount of 31 pounds of water, or more than half a pound of water for each pound of air, which is double the average consumption and four times the capacity of ordinary air for moisture.

It will be observed, also, that a great reduction of temperature from 324° to 190°, or 126°, was found in the two runs.

The large quantity of vapor and heat abstracted from the water in the first run will fully and satisfactorily account for the small quantity of air consumed, and would serve to indicate the possibility of increasing the distance run by burning gas or petroleum to replace the heat which the air absorbs. There must, however, always be a loss of power when air, after being compressed, is expanded to a lower tension without work.

In the last run of the second series 100 pounds were consumed. This was to have been expected, as the water at the end of the run was 32° below the boiling point.

On Tuesday, March 11th, further experiments were made to determine the effect of attaching additional cars to the motor. The following is the record taken by Mr. Harley:

| | |
|---|---|
| 1st trip started from 127th street with.. | 300 pounds. |
| At depot, 97th street, air pressure.. | 250 " |
| Consumed in half trip .......... | 50 " |
| Coupled on 2 ordinary street cars, pressure at end of trip, 127th street.......... | 170 " |
| Consumed with the 2 cars and motor | 80 " |
| Temperature of water.......... | 205° |
| 2d trip started with.......... | 335 pounds. |
| Run at mean pressure.......... | 150 " |
| Cars in tow .......... | 2 |
| Pressure at 97th street.......... | 275 pounds. |
| Consumed.......... | 60 " |
| Water used.......... | 14·2 " |
| Reduced pressure in heater to .... | 130 " |
| 2d trip, return, 2 cars in tow, started 97th street, pressure .......... | 275 " |
| Pressure at 127th street.......... | 190 " |
| Consumed pressure.......... | 85 " |
| Water used.......... | 14·2 " |
| 3d trip, heated water again; 2 cars started from 127th street with a pressure of.......... | 330 " |
| At 97th street, pressure.......... | 265 " |
| Consumed .......... | 65 " |
| Water used .......... | 16 " |
| Return, no cars in tow, started from 97th street .......... | 250 " |
| At 127th street.......... | 200 " |
| Consumed .......... | 50 " |
| Water used.......... | 11 " |

OBSERVATIONS.

It appears that the two up trips consumed 80 and 85 pounds of pressure, and the two down trips 60 and 65 pounds, and the up trips required 33 per cent. more than the down trips. This may be due to the very bad condition of the up track. The average round trip required 145 pounds, with two cars attached to motor, as against 90 pounds, with motor alone, an increase of 60 per cent., or 30 per cent. for each car hauled. The two cars probably weighed as much as the motor, and, if so, the traction of the cars would be 15 pounds per ton, assuming the motor at 25.

The data furnished by observations on the motor will serve to indicate the loss of power and of work in transmission from the piston to the rail, starting at 350 pounds pressure, the run of 9¾ miles was made with 270 pounds pressure, or 90 pounds per average run, or 298 cubic feet of air at atmospheric density per mile. Assuming for the present that the effect of heating and moistening the air is chiefly to compensate for the reduced temperature in expanding, and to secure the full benefit of isothermal expansion, the foot pounds of work per mile will be computed on this basis.

The volume required per mile to fill the capacity of the working cylinders is 720 cubic feet; the 298 cubic feet, therefore, filling 40 per cent. of the cylinder capacity, leaving 60 per cent. to be replaced by air from the exhaust passages by the opening of the suction valves.

If used under on average pressure of 170 pounds, $=11·33$ atmospheres indicated, or 12·33 atmospheres actual, the atmospheric pressure would be reached in $13 \times ·4 = 5·2$ inches of stroke in cylinders, and the mean piston pressure during the 5·2 inch stroke would be 1,732 pounds.

As there are 4 cylinder discharges to each revolution, and 720 revolutions to a mile, the travel of piston per mile run under pressure will be $720 \times 4 \times 5·2 = 14{,}976$ inches $= 1{,}250$ feet and $1{,}250 \times 1{,}732 = 2{,}165{,}000$ foot pounds of work done at piston per mile of actual run. If now it requires a tractive force of 25 pounds per ton on a level road to move the motor, and the weight be 8 tons, then $8 \times 25 \times 5{,}280 = 1{,}056{,}000$ foot pounds per mile, which, if the road was level, would represent the actual work utilized from an expenditure of of 2,165,000 foot pounds upon the piston, which is 50 per cent. nearly.

It would appear, therefore, that only half the power applied to the piston is actually utilized in propulsion on the track, and the balance must be expended in overcoming friction of motor and other resistances and losses. The power required to move the motor, if applied externally, and also the traction of the ordinary horse cars, is not known, and should be determined.

The computation of average run has been based on an expansion of twelve, and reaching atmospheric tension at ·4 of the length of the cylinder, using only one-thirtieth part of a cylinder of air at each stroke. If a full cylinder of air should be used, the power on the piston would be increased nearly nine times, but the consumption of air, thirty times.

This great reserve of power over the average for ordinary work is an advantage of no small importance. The reserve of power can be drawn upon to overcome great resistances, if of short duration.

As an illustration of this fact, and since the above paragraph was written, Mr. James states that on one occasion the motor got off the track at a sharp curve and switch at the 127th street depot. A ditch had been dug for gas pipes and filled in, but not paved. The hind wheels sank in the ditch until the frame of the motor rested on the pavement. A high pressure was let on, and the machine pulled itself out without further assistance.

The writer cannot close this report without an acknowledgment of the valuable information that he has received from the company's engineers, Messrs. Hardie and James, whose remarkable ingenuity and mechanical skill have secured the results detailed in this report. Mr. James is not only an accomplished machinist, but an expert mathematician, a Bachelor of Science, and a graduate of the University of Edinburgh.

Mr. Reynolds, the engineer of the Delamater Works, is too well and too favorably known to require indorsement from any one. The Pneumatic Tramway Engine Company have certainly been fortunate in securing an unusual combination of talent in their mechanical engineering department, and to this the success of the motor must be largely attributed. H. Haupt, Consulting Engineer.

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## HOW MONEY IS MADE.

By A. E. Outerbridge, Jr.

Although the United States Mint is a never failing attraction to visitors, it is probable that but few obtain more than a very superficial glimpse of the manifold chemical and delicate mechanical manipulations through which the precious metals must pass before evoluting into the noble double eagle, or the bright new silver dollar; and it is perhaps with a slight feeling of disappointment that the visitor, after completing the circuit of the operative rooms which are open to public inspection, is ushered into the cabinet of coins and politely invited by the guide to make himself perfectly at home, stay as long as he likes, and "look at the coins of all nations and specimens of gold from all parts of the world."

It is with the view of partially satisfying the curiosity which may have been whetted by such a visit that this descriptive article is written, and it is proposed to give the reader a little glimpse behind the scenes, and to initiate him into some of the delicate means by which the noble metals are prepared to receive the impress of Uncle Sam's bird of freedom.

The early history of the precious metals forms an exceedingly interesting subject of research, but an attempt to explore this tempting by-path of knowledge would be impossible within the brief space of one article.

The precious metals are never found in the pure state, and they are deposited at the mint alloyed with other metals and in a great variety of forms, such as native grains, dust, amalgam, bars or pigs, old jewelry, etc. The mixed metals are known under the generic name of "bullion."

The bullion is first weighed in the "deposit weigh-room," where several balances are kept for the purpose; the largest of these will weigh as much as ten thousand ounces in one draught, and the scale will readily turn, even when loaded to its full capacity, with a weight of one hundredth part of one ounce. The metal is then placed in a box provided with a cover and lock and taken to the "deposit melting room." Here it is put in a crucible which has been previously heated in the melting furnace and covered with a thin coating of borax, which forms a sort of fluid glass, acting as a hermetic cover to protect the metal, when it is molten, from the oxidizing influence of the air. A stalwart workman, wearing a pair of large canvas mitts (somewhat resembling boxing gloves) stands guard, and grasping, with a pair of iron tongs, a rod or stick made of plumbago, he stirs the now fluid mass back and forth, up and down, round and round, for the purpose of rendering it thoroughly homogeneous; the metal is then cast into an iron mould called a "shoe." It is plunged into water to cool, as well as to dissolve off any particles of the borax glass which may have adhered to its surface. It is now returned to the weigh room and reweighed.

A slight loss in weight usually occurs owing to a practical refining out of the base metals, and the new weight is the amount with which the depositer is credited.

Let us suppose that a depositor brings a miscellaneous assortment of old gold; watch cases, jewelry, dentist's plates, etc., representing every grade of fineness or proportion of pure gold, desiring to obtain its equivalent in coin. We will follow in imagination the usual course pursued.

After the metal has been returned from the melting room (where it was cast into the shoe mould) and the bar reweighed, a small chip is cut off from one end of the bar and taken to the assay laboratory.

THE ANALYSIS.

The sample is laminated or rolled into a thin ribbon and stamped with the number of the deposit which it represents, it is then assayed to determine the proportion of gold, silver, and base metal, and so accurate are the processes of assay, that the exact value of a deposit, frequently aggregating many thousands of dollars in value, is determined to the fraction of a cent by calculations based on the assayer's report.

The largest weight which the assayer uses in making an analysis of gold bullion is the French half gramme (or about seven and three-quarters grains troy).

The balances used in this work are marvels of mechanical construction; they are so sensitive that a weight of one-

twentieth of a milligramme (less than one-thousandth part of a single grain) will cause the indicator needle to deflect a very appreciable distance from the zero point on the graduated scale marking the equilibrium. These little balances are inclosed in glass cases, provided with sliding windows to exclude any draught of air. The beam is usually made of aluminum, one of the lightest metals, and the knife edges rest on jewels. The weights are made of gold, silver, and aluminum, and are graduated from the half gramme, which is arbitrarily denominated "1,000," down to the ten thousandth degree.

The assayer first determines approximately the relative proportions of the metals existing in the alloy, and from this bases his more careful determinations; he weighs out on the balance exactly one-half gramme, or 1,000 parts of the alloy; he wraps this in an envelope of pure lead and rolls it into the form of a "bullet." The bullet is then placed in a small "cupel" or cup, made of calcined bone dust, which has been brought to a white heat in the muffle or oven of the assay furnace.

The mass melts immediately, and the lead oxidizes rapidly by absorbing oxygen from the heated air which passes continually over its surface, and on account of the extreme fluidity of the oxide it sinks into the pores of the cupel, which absorbs it as readily as a sponge absorbs water; the lead also carries with it all the base metals which may be originally combined in the alloy, but the precious metals not being oxidizible, simply melt, and are not so fluid as to be capable of sinking into the cupel. A preparation thus takes place, and at the moment when all the base metal is removed a beautiful "flash" is observed to take place on the surface of the metal; the "button" of purified gold and silver resulting from this operation is then removed from the cupel, returned to the balance, and weighed; the loss indicates the proportion of base metal. Another weighing of the sample is then made, to which is added pure silver in the form of fine granules, in the proportion of about two parts of silver to one of gold, the alloy is inclosed in a sheet of lead and cupelled as before; the silvery button remaining is laminated, coiled into a roll called a "cornet," and boiled in nitric acid. The acid dissolves the silver, leaving a little roll of pure gold. This gold cornet is then annealed in the furnace to give it toughness, and is finally weighed; this weight represents the proportion of pure gold. The proportion of silver is ascertained by subtracting the weight of the pure gold plus the weight of the base metal from the original weight of the assay sample.

Silver was formerly assayed in the same way, but it was long known that the result was not quite accurate, owing to a partial volatilization of the metal when exposed to the high temperature of the fire. Experiments were some years since instituted by the French government to overcome this difficulty, which resulted in the beautiful "humid process" devised by a celebrated chemist, Gay Lussac. This is one of the most accurate methods known to chemical science, and so complete was Gay Lussac's original description that but little room has been left for any improvements, and many thousands of dollars' worth of silver bullion are rapidly and accurately determined every day in the mint in this way. The rationale of Gay Lussac's method is very simple, viz., a given amount of chlorine gas will precipitate a definite proportion of pure silver from its solution in nitric acid.

The assayer prepares two solutions of common salt water (chloride of sodium); one is known as the "normal solution," and the other as the "decimal solution." One begins and the other finishes the assay.

The sample of silver to be assayed is weighed out, as in the case of gold, the assayer taking care to place a sufficient weight of the alloy in the scale pan to contain at least one gramme (a little over fifteen grains) of pure silver; the weighed sample is then placed in glass bottle and a charge of nitric acid is added to it; the acid is caused to boil, and in a short time the silver alloy is completely dissolved.

A charge of the normal salt solution is then allowed to flow into the bottle from a glass "pipette," which is made of such a capacity that it shall contain just enough salt water to precipitate one gramme of pure silver; the chlorine in the salt water combining instantly with the silver, precipitates it in the form of a white cloud; the bottle is agitated rapidly for a few moments, when the precipitate settles to the bottom, leaving a clear solution above; the assayer next allows a charge of the "decimal solution," which is one-tenth the strength of the normal solution, to flow into the bottle from a glass tube with graduated divisions, each division marking one-hundredth the capacity of the large pipette. If any silver remains in the solution a cloud will be observed on the surface. Now, as this decimal charge is one-tenth the strength and one-hundredth the volume of the large pipette, it will, of course, precipitate just one-thousandth as much silver, or one milligramme. The bottle is again agitated to settle the precipitate, and successive charges of the "decimal solution" are added until all the silver is precipitated, and then a simple rule of three sum gives the exact proportion of pure silver contained in the original weight of the alloy. The assayer guards against all probable sources of error by an elaborate system of checks, and each set of assays is accompanied in all its mutations by one or more "proofs" or synthetic assay, made either from pure metal or from alloys of known composition.

After the exact proportions of gold, silver, and base metal constituting the alloy are reported by the assayer to the superintendent the value of the deposit is calculated, and the depositor is paid the full equivalent, less the charges for refining, the amount of charges depending, of course, upon the nature of the bullion.

THE REFINING PROCESS.

The metal now passes into the hands of the "melter and refiner."

We will suppose that the representative deposit that we have already alluded to contains a small percentage of base metals, such as tin and lead, which tend to make the alloy brittle or "short," rendering it unfit for coin. The first operation to which it is subjected is intended to eliminate these impurities, and is called "toughening." The metal is melted in a crucible and an oxidizing flux (saltpeter) is added to it while fluid, the saltpeter or niter decomposes and liberates oxygen gas; the oxygen seizes the base metals forming oxides; these rise to the surface and are dissolved in the flux; the flux, when sufficiently thick, is skimmed off, and the purified metal, consisting only of gold and silver, is cast into a bar or poured into ice water to form granulations. The next operation is designed to remove the silver; this is effected by boiling in nitric acid, when the silver dissolves, leaving the gold in a finely divided state.

The "plant" used for this purpose consists of a number of large porcelain jars capable of holding about fifty gallons of nitric acid each. These are arranged in a double row and heated by steam pipes; they are inclosed in a chamber provided with sliding doors to prevent the escape of the noxious fumes, which are carried into a tall chimney from which they issue in a yellowish cloud. The dissolved silver is drawn off by means of a large siphon made of native California gold (valued at three thousand dollars) and transferred to a vat made of wood, resembling those used in breweries. The vat contains several hundred gallons of salt water, and the silver is precipitated by the chlorine, a workman facilitating the operation by agitating the liquid with a large paddle provided with a long handle.

The precipitated silver is drawn off into large filters placed on trucks and thoroughly washed by running water until the test of litmus paper shows that all trace of acid has been removed. The chloride of silver now resembles pure white cottage cheese. It is transferred to another vat lined with lead. Zinc (which has been previously granulated by pouring while melted into cold water) is added to the silver, together with a little sulphuric acid; the chlorine deserts the silver for the baser metal, forming a soluble salt of zinc. The solution is allowed to flow off, and the precipitated silver is pressed into round cakes called cheeses, dried in an oven and melted in the furnace; it is finally cast into a bar, and is found to be uncontaminated with its former base associates.

The gold which remained in the porcelain jars is in the form of fine powder, and resembles sifted gravel as nearly as may be. It is also pressed into cheeses, dried, and melted under a covering of borax or charcoal, and cast into a bar of nearly pure gold.

All that now remains for the melter and refiner to do is to weigh out the requisite amount of copper to form the coin standard, which is nine parts of gold or silver (as the case may be) and one part base metal. In other words, our coin standard is nine-tenths fine.

The alloy is melted in large crucibles made of plumbago and constantly stirred to render the mass homogeneous. The standard metal is cast into flat bars called ingots, twelve inches long, one-quarter of an inch thick, and from three-quarters to one and a half inches wide; the ingots are filed to remove the ragged edges, and the rough tops are cut off with large steam shears. Two samples from each melt are assayed, and if the alloy is found to be of the proper fineness and of uniform composition, they are delivered to the coiner.

THE MECHANICAL PROCESSES.

The coiner transfers the ingots to the rolling mill, and when they have been sufficiently laminated by successive rolling and annealing, the strips are passed through a machine called the "draw bench," for the purpose of reducing them to the exact thickness required for the coin; this operation is similar in principle to wire drawing, and consists simply in squeezing the flat strips of metal between two stationary steel cylinders set to the desired gauge. The strips are now passed to the cutting press, which consists essentially of a round punch, the size of the "planchet," or blank required for the coin, working up and down very rapidly into a hole on the steel bed plate.

The strips are passed by hand through the press, and the blanks fall into a box below. The unused portion of the strips, or "clippings," is returned to the melter and refiner and remelted. The planchets are next taken to the "adjusting room," where may be seen a number of ladies seated at a long table, each one provided with a little balance and a file. Every lady is supplied with a pile of planchets, and she proceeds very deftly to weigh each one against a properly adjusted counter-weight. The planchets that are too light are thrown into a separate pile and returned to the melter and refiner, to be remelted with the clippings, while those that are too heavy are adjusted by filing on the edge. Within a very few years a novel automatic adjusting machine, designed by Mr. Ludwig Seyss, of Vienna, has been introduced for the purpose of facilitating the work and diminishing the necessity of hand labor. It is an exceedingly beautiful and ingenious piece of mechanism, but is too complicated to admit of an intelligible description without the aid of sectional drawings. A description of this instrument will be found in the Journal of the Franklin Institute. It not only weighs the blanks automatically, but separates them into three kinds; those that are too heavy falling into one box, the light ones into another, and those of the right weight into a third. The machine never makes a mistake, and will weigh and assort as many pieces in an hour as five expert ladies can do by hand, but when we consider that there are ten balances in the machine engaged in weighing at the same time, and only five used by the ladies, they must be awarded the palm for expedition.

The machine also requires the constant attention of one person to supply the blanks or planchets, and when the additional cost of steam power and wear and tear of the parts are added to the original expense of the apparatus, its merit from an economical point of view is not so great as would at first sight appear.

The next operation to which the blank pieces are subjected is to impart the raised edge, technically called "milling."

The machine used for this purpose is an American invention, and is admirable for its simplicity as well as for the rapidity with which it accomplishes the work.

The blanks are fed by an attendant into a tube, and they are drawn horizontally, in single file, through a gradually narrowing channel formed by a groove in the periphery of a rapidly revolving disk on one side, and a stationary segment of corresponding curve on the other, keyed a little closer to the wheel at one end. The blanks are in this way compressed on the rim, acquiring the "milled edge." This machine is capable of milling as many as 1,200 pieces per minute.

The blanks are now taken to the pickling vats, where they are immersed for a couple of minutes in weak sulphuric acid for the purpose of removing the black oxide of copper; they are then washed in pure water and placed in a rotating cage filled with sawdust. This rapidly dries the blanks, and when removed to the coining room they have acquired a fine, bright surface.

THE COINING.

The early methods of coining were exceedingly crude and imperfect. The metal was hammered into a thin plate; pieces of irregular size were cut out and beaten into a bullet shape; this bullet was placed on a sort of anvil having the reverse die cut upon its face.

The obverse die was held in the hand like a punch, and by the aid of a heavy hammer the bullet was flattened out and coined at the same time.

There are many interesting specimens of this antique coinage to be seen in the mint cabinet. The oldest pieces are to be found in the case devoted to coins of the Greek Republic, dating back to seven centuries before the Christian era. It was not until the middle of the sixteenth century that the forge and hammer were succeeded by more scientific methods.

In the British mint the coins are struck in presses worked by a screw; but we have adopted the admirable invention of a Frenchman, named Thenollier, which has been further improved upon by the skill of a former coiner, the late Mr. Franklin Peale. This machine operates on the mechanical principle of the "toggle joint" (of which the elbow-joint is a familiar example). It is controlled by a lady who feeds it with the blanks, which she places in a vertical tube. A pair of "feeders" catch the bottom piece and carry it forward, where it rests in the "collar" between the upper and lower dies; the lever is now descending with the upper die while the lower die remains fixed; the pressure increases with perfect uniformity up to the maximum, which is equivalent to about 10 tons for the dime, 80 tons for the double eagle, and 120 tons for the silver dollar. The pressure gradually decreases again by reason of the relaxation of the upper joint, the lower die pushes the piece out of the collar into which it has expanded, and from which it acquires the "reeded edge." Meanwhile, the feeders have provided another blank, and as they bring it forward they push the coined piece into a channel, through which it slides into a box beneath the machine. The coins are then inspected by the foreman, and any cracked or defective pieces set aside.

The larger denominations of coin are counted by hand, and the smaller pieces, as well as the "bronze" and "nickels," are numbered by means of a simple and ingenious arrangement called the counting board.

After the coins have thus been counted and weighed, they are tied up in linen bags and delivered to the treasurer in drafts of $5,000 each. The accuracy of the adjustment of the weight is so nice that there is rarely a deviation from the true standard weight of as much as one hundredth of an ounce in any delivery of either gold or silver coin.

As a final precaution, the assayer is required by law to select at random one coin from every lot of twenty thousand dollars; these are sealed in envelopes, numbered, and placed in a strong box provided with two locks; the key of one is kept by the treasurer and the other by the assayer. These sample pieces are called the "pyx." They remain sealed until the commissioners appointed by the President assemble at the "annual assay" in February of each year to test their purity and weight; and it has rarely, if ever, happened that any piece has been found to exceed the small limit of "tolerance" allowed by law.

The manufacture of the dies for coin requires a high order of artistic and mechanical labor, involving "the talent of the designer and the skill of the engraver and sculptor." A detailed description of the processes involved would necessarily extend this article beyond the limits assigned to it. A brief outline must, therefore, suffice. The artist first makes a free sketch on paper, he then models his design in wax upon a glass plate, and it is probably five times the size intended for the coin; from this he takes a cast in plaster, which serves, when coated with plumbago, as a matrix from which an electrotype in copper is obtained. The electrotype rilievo, after being finished by hand, is used as the model from which the steel die is cut by means of a reducing pantographic cutting machine, somewhat similar to those used for reproducing designs for steel rolls used in making printed fabrics. A traveling pointer attached to the long arm of a lever is caused to move back and forth over all portions of the raised model, and a steel drill attached to the short arm is thus caused to cut an intaglio design in a block of steel corresponding in all its details to the model, but reduced to the proper diameter for the coin; the stars and lettering are now added, and the whole is finally touched up by the hand.

This intaglio is not used for coining, but from it a rilievo called the "hub" is made. A block of steel having been softened by annealing, is placed in a screw press carrying the "hub," and by a succession of blows, followed by frequent annealings, the die from which the coin is to be made is produced.

It is possible (owing to the great value of the raw material) to bring the processes involved in our gold and silver coinage to a perfection which would not perhaps be found profitable in any ordinary industry, and this fact, together with the national pride which is felt in the matter, should offer encouragement to the invention of all practicable methods of producing perfect work and preventing losses.

## POROSITY OF STONE.

Professor Doremus, of the Buffalo Medical College, recently performed an interesting and instructive experiment before his class. A block of sandstone, such as is usually employed for window caps and sills, and about twelve inches square and four or five inches thick, had a panel one-half an inch deep sunk in each side. In each panel was fitted a block, which was perforated by a piece of common gas pipe, and this was cemented about the edges. The whole was then coated with an impervious varnish. Air now entering the pipe on either side had access to the clean surface of the stone beneath the panel, and it was found that if the mouth be applied to the protruding pipe on one side, and a candle be placed in front of the opposite one, it could very readily be blown out by the air, which, with very little effort, was forced through the stone. When a rubber tube was connected with the house gas pipe on one side of the stone, and a burner was attached on the opposite side, the simple pressure from the gas mains was sufficient to force the gas through the stone till it was lighted at the burner on the opposite side. When by any means the pressure was increased, a very large flame was thus produced.

## DISASTROUS EARTHQUAKE IN PERSIA.

We recently published news of an earthquake which had occurred in Persia. The following particulars have now reached us, and unfortunately show that the loss of life and damage to property as stated in the original report were in no way exaggerated: "On the 22d of March, at 3:42 A.M. (London time, 12:37 A.M.), a severe earthquake, lasting 12 seconds, was felt here (Tauris) and east as far as Zeudjan; no damage was caused in this city, but in the vicinity of Mianeh, where the shocks continued with more or less vigor up to the 2d of April, great damage and loss of life have occurred. An official report prepared for the Persian Government by the Persian Telegraph authorities at Mianeh gives the damage, as far as is at present known, as follows: 21 villages totally destroyed, 54 greatly damaged, 922 persons killed, together with 2,660 sheep, 1,125 oxen, 124 horses, and 55 camels. The center of the disturbance was the mountain of Bouzgouche."—*London Times.*

THE SPIRE OF LA GIRALDA, SEVILLE, SPAIN.

## THE SPIRE OF LA GIRALDA, SEVILLE, SPAIN.

AMONG the most precious architectural jewels which the genius of the Arabians bequeathed to us, this famous tower, generally known as the Giralda, stands in the first rank. We present an engraving of the structure, for which we are indebted to our elegant contemporary *La Ilustracion Española y Americana*, of Madrid. It is well known that the construction of the first story of this structure was begun A.D. 1000, under the direction of the wise Moor, Huever, who gave it an altitude of 250 feet; and it thus remained until A.D. 1569, when it received its beautiful spire from the hands of the famous Spanish architect, Fernan Ruiz, who added the four upper stories and increased the height of the tower to 350 feet. We will not undertake to give a description of the Giralda, for it would occupy too much space; it may be found minutely stated in various histories of the city of Seville. We will only mention that the first bell clock ever known in Spain was placed in the tower of the Giralda, on the 17th day of July, A.D. 1400, in the presence of King Henry III. The mechanism of the clock was destroyed by an accident in 1404, but was reconstructed and replaced about the middle of the last century by friar Jose Cordero, his work being of singular merit on account of its exactness and beauty. In one part of the structure, popularly called the little Giralda, there are twenty-four bells, the largest of which is St. Mary, ordered to be constructed by Archbishop Gonzalo de Mena, and placed in position A.D. 1588. When all these bells join their voices to the general chiming with which the great feasts of the church are solemnized, their sounds, harmonically combined, dominate in happy concert all other tones that ring throughout the city.

The spire of the tower is crowned by a colossal statue of Faith, which serves as a gyrating weathercock, from which the tower takes its name of La Giralda. The panorama which meets the view of the traveler who ascends this famous tower, is said to be of surpassing beauty.

## SCULPTURE IN GOLD AND IVORY.

AN interesting paper on "Sculpture in Gold and Ivory" appears in the *Magazine of Art* for May. We have, remarks the author, not so much as a fragment of any of these wonderful chryselephantine statues of ancient Greece remaining, nor have we more than scanty notices of how they were put together, and what they were like. The general tendency of modern theories leads to the conclusion that though the materials of which sculptors make use should be of fine grain and pure whiteness, such as Pentelic or Parian marble, yet that little reliance is to be placed on the splendor of mere material, and that the mind should be directed rather to the deep and imaginative beauty which the artist has embodied in his sculpture. Statues of gold and ivory are to some extent in contradiction to such teaching, true as it is when broadly stated. There were many of these chryselephantine statues in ancient Greece.

The most famous were those of Zeus (Jupiter), at Olympia, of Here (Juno), at Argos, and of Athene (Minerva), at Athens. They were of colossal size. That of Zeus was from fifty to sixty feet high, on a pedestal of twelve feet. That of Athene was perhaps forty feet (twenty-six cubits). They have been described but vaguely by various authors—by Pausanias, who saw these as well as many others in the second century of our era. The faces, arms, legs, and all uncovered portions of the limbs were of ivory; the dresses, which hung, in the case of the Athene, in straight but ample folds to the feet, were of gold; the borders and edges were highly wrought.

The Zeus sat in a chair (such, probably, as some seated statues in the British Museum are provided with) made with massive square bars and backs, at the four supports of which stood four Victories. In one hand he held a life-sized Victory, in the other, a tall scepter surmounted by his emblematic eagle. The scepter was of various metals; the throne, or chair, was of cedar wood, inlaid with ivory, ebony, and precious stones, and had on it figures and groups in relief. The footstool of the god stood on four lions, and the pedestal on which the whole was raised was covered with figures in relief.

The Athene in the Parthenon was standing. The face, arms, and feet were of ivory. The eyes were of marble, or *pietra dura*. On the head was a helmet, surmounted by a sphinx in the round, with griffins on either side in relief. Contests with centaurs were executed in relief on her Tyrrhenian sandals. She held a spear in one hand, and a life-sized Victory, considered a work of extraordinary beauty, in the other, and had a shield and a serpent at her feet behind her. She wore an ægis, or breast-plate of gold, on which was a Medusa's head of gold, replaced, when Pausanias saw it, by one of ivory. The shield had the battle of the giants on the inside, that between the Greeks and the Amazons on the outside, and in this part the portraits of Pericles and Phidias himself were ingeniously introduced. This fact led to a subsequent accusation of impiety. On the pedestal was the birth of Pandora.

The gold on these statues was hammered, and of no great thickness; said to be "a line," perhaps as thick as the eighth of an inch. The throne of Zeus has been already said to have been of cedar. An olive wood and cedar frame was the structure on which the Athene and other such statues were made up. There remain on coins various typical representations of the Zeus and of the Athene, and there are in the Museum of Athens and the Vatican antique statues considered to represent them (see "Museo Borbonico," vol. iv., plate 7, for instance), and the Pallas of the Villa Albani. A bust of Zeus, with huge locks of hair, in the Museum of Naples, is also considered to represent the head of the Colossus at Olympia.

All the great artists who were contemporaries or pupils of Phidias worked at the statues we have described, or took special parts, such as the inner and outer sides of the shield, the sandals, pedestals, and so on. The golden drapery of the Athene seems to have been so laid on that it was movable; at any rate, the artist had it taken off and weighed when accused of peculation. The entire weight of gold was about forty talents, and the value in our money was about £120,000 sterling, a great sum in those days.

The question will naturally be asked, how such surfaces as a face nearly five feet high—or, in the case of the seated Zeus, twice as large—the arms and limbs could possibly be made of ivory? The material was laid on olive wood, and was probably glued down with excellent animal size (in the opinion of De Quincy, pegged down to the wood). However large the teeth at the artists' command, the pieces must have been joined. The ancients are said to have been acquainted with methods of softening the edges and joining together slices or slabs of ivory something in the way in which tortoise-shell is still joined. Oil was constantly rubbed or poured over the Zeus to preserve the ivory, and the vapor of water had a similar effect on the Athene in the Parthenon. It must be remembered, also, that, in consequence of the immense scale on which these statues were made, the lines or cracks that might be seen on small carvings close to the eye would not be generally perceptible. There remains one more question regarding these sculptures: Was the ivory left white or painted? We know that the architecture, probably also the sculpture, of the Parthenon was painted and gilt. Were not most of the statues of the Greeks painted also? If the eyes of the Athene were inlaid in marble, or lapis-lazuli and other stones, was her face left without color? We have no definite information on this point, but there is some probability that even the ivory may have been treated with color laid on with size or wax. Such a treatment would tend to preserve the material, and we know that these large statues remained entire in the second century of our era, and were probably not taken to pieces till the fourth.

The example set by the artists of the time of Phidias was followed in a number of sacred places in Greece, and it became a sort of fashion to have such statues in the rich temples of the Roman dominions. Numbers are said to have been made in Athens, Corinth, and other wealthy Greek capitals for exportation, long after the loss of Greek independence.

We must not omit a notice of an effort, the only one that can be mentioned in modern times, to revive this costly kind of sculpture. The late Duc de Luynes had a statue of ivory, silver, and bronze, a Minerva, made by a French sculptor, M. Simart. It was exhibited in Paris in 1855. It measures nearly ten feet in height. The face, neck, arms, and feet are of Indian ivory, as well as the torso of a small Victory held in her right hand, and the Medusa's head on the ægis. The spear, shield, helmet, and serpent are of bronze; the drapery and the ægis, or breast-plate, are of beaten silver, carefully chased with the graver.

We have no record of any similar attempt during the Italian Renaissance, that period so fruitful, not only in excellent sculpture of bronze and marble, but in the production of carved ivory, intaglios, and gems, in every kind of costly and precious material. But it must be remembered that the Italian Renaissance had but few remains of Greek workmanship as examples for the artists of the day. The excavations and discoveries then made were of Roman art. The Romans of the empire were rich and luxurious, and employed Greek artists and workmen, who copied and reproduced in countless quantities the famous works of an earlier period, many of which, no doubt, were brought to Rome, but were in the possession of the Emperors, or were given by them as public monuments to the temples, or were erected to adorn the *fora* and other public places of the city. A statue of Minerva, for instance, all of ivory, the work of Endœus, which had been long preserved at Tegæa, was placed by Augustus in his new forum.

Statues of this perishable material left uncared for, or exposed to violence in the troubles which brought the empire to ruin and disruption, could not be expected to survive. Nor has anything of the kind been brought up hitherto from the buried cities of Herculaneum and Pompeii.

It must be observed, in conclusion, that it would be an error to suppose that the excellence of the art was in any way lost in the splendor of the substances used in these statues. On the contrary, the great artists contrived to make their material set off the grandeur of the general design. The face and arms of the Zeus—vast surfaces—and distant portions, such as the hair, were broadly treated, some of the locks, according to Lucian, weighing six minæ, valued at "300 louis d'or." On the other hand, the bars of the seat, the sandals, footstool, and pedestal were covered with small, even minute work, and finished like jewelry, golden drapery being painted or enameled with flowers. These parts came close to the eye, and being under cover, could be examined thoroughly. Such small and elaborate details in the first place, and then the life-sized figure of Victory, would give some measure of the colossal scale of the rest. Contrasts of this kind fill up the idea of completeness and finish which we so often miss when we come near or close under pieces of colossal sculpture.

It is difficult for the mind to call up for itself anything like a graphic vision of glories so utterly gone, and of which some few of the details only have been mentioned, but mentioned as matters supposed to be well known, and not, therefore, carefully described. We want Michael Angelo, Cellini, the jewelers whom he taught, and the minute skill of Japanese metallurgists to work together in order to give us some just notion of such perfect art. The great men of the sixteenth century attempted no such cycles of sculptured completeness. We can only find some sort of parallel to them in the great shrines and churches of the Middle Ages and the sixteenth century.—*Building News.*

## NOTES ON PORCELAIN PAINTING.

By VICTOR JOCLET.

*Blue Colors.*—For the preparation of these colors carbonate of cobalt is generally employed alone. Experience shows that the excellence of the colors produced depends on the absolute chemical purity of the cobalt. Nevertheless an oxide of cobalt contaminated with arsenic is often used, as the chemically pure article is difficult to prepare, and cheapness is as much taken into consideration in this art as in many others. Dark blues are obtained by mixing equal parts of cobalt oxide, zinc oxide, lead-glass (the latter produced by melting together 2 parts of red lead, 1 part sand, and 1 part calcined borax), and 4 parts of flux A (produced by melting together 2 parts red lead, and 1 part white sand), the whole being afterwards melted together in a porcelain crucible, and kept at a red heat for at least two hours.

Turkish blue (soft), of very good quality, is thus produced; 160 parts burnt alum, 1 part oxide of cobalt, ¼ oxide of zinc, and intimately mixed, thoroughly ignited; a flux of 85 parts red lead, 32 borax, and 3½ silica is added, and it is then ready for use.

A very bright light blue is obtained by grinding together 1 part oxide of antimony, 4 cobalt blue, 1 oxide of tin, and 1 of flux A.

As a blue for shading, the author recommends 5 parts oxide of cobalt, 4½ parts oxide of zinc, 12½ of flux B (2 parts red lead and 1 part white sand).

Robert recommends the following formula for a lively medium blue: Dissolve 6 parts oxide of cobalt and 2 parts oxide of zinc in muriatic acid; add 92 parts of alum dissolved in water; filter and neutralize the filtrate with carbonate of soda. The white precipitate thus obtained is washed with abundance of water, dried, ground fine, and heated to dull redness in a crucible, gradually raising the heat. The crucible is then taken from the furnace and allowed to cool gradually.

Dr. Wachter prepares a very fine Turkish blue by dissolving 3 parts of absolutely pure oxide of cobalt and 1 part oxide of zinc in sufficient sulphuric acid; then dissolving 40 parts of ammonia alum in water, mixing the solutions, evaporating to dryness, and heating the residue till the water is completely expelled. The residue is then submitted for several hours to a violent red heat. The color turns out best if placed along with a batch of porcelain in the annealing furnace. It is a combination of 1 equivalent of alumina, 3 of oxide of cobalt, and 1 oxide of zinc. Other proportions give inferior colors.

If there are added to the blue colors small quantities of protochromate of mercury (mercurous chromate) recently precipitated, and still moist, greenish shades are obtained.

If the above-mentioned colors, after being burnt upon the porcelain, are examined under the microscope, they do not appear as homogeneous blue enamels, but as a mixture of a colorless blue body and of a colorless glass. The former, according to Wachter, is probably aluminate of cobalt.—*Chemiker Zeitung.*

## DYED COCOONS.

A SPANISH silk spinner has hit upon the ingenious idea of adding dyes to the warm water which is used for detaching the silk fibers from the cocoon, and thus to dye the fiber as it is being formed into thread. His object is to obtain a dyed thread which is to contain all the natural gum and luster, and which, on that account, will retain the color more easily and readily.

## DYEING RECEIPTS.

*Navy Blue for Ladies' Cloth.*—For two pieces of 44 lb. First bath 4 lb. soda and ¾ lb. Prussian blue, in which the cloth is turned for an hour, at a temperature of 200° Fahr.; it is then washed and placed into the second bath, strongly acid, and containing 10 oz. methyl violet, and finished within the boiling heat.

*Fast Black for Cotton Yarn (for 100 lb. Yarn).*—24 lb. extract of logwood are dissolved in hot water, 1½ lb. Cyprus vitriol added, the boiled yarn introduced and turned a few times, then washed. A second bath is formed cold of 2 lb. bichromate of potash and 1½ lb. nitrate of iron; the yarn passed through this, then back again to the first bath, with the addition of 2 lb. olive oil and 2 lb. soda.

*Olive Bronze for Half Silk Yarn.*—6 lb. prepared cutch, 3 lb. yellow cutch (*Terra japonica*), and 2 lb. Cyprus are boiled together, then the bath cooled down to about 100° Fahr.; the yarn, 50 lb., introduced, turned for three hours taken out and placed into a fresh hot bath, darkened with 2 lb. bichromate of potash, passed for half an hour into the first bath, with the addition of 4 lb. curcuma, and darkened in a fresh cold bath with nitrous iron (nitrate of iron ?) up to the required shade.

*Russian Green for Cotton Yarn.*—After having been well boiled the yarn is brought into a boiling bath of 20 lb. sumac and 1 lb. logwood extract, left in this over night, and placed into a cold bath containing 4 lb. copperas and 6 oz. Cyprus vitriol, turned for an hour, taken out and placed again into the first bath, turned about ten times, and dyed in fresh tepid water, containing ¾ lb. methyl green, and shaded in the same bath, according to wants, with decoction of fustic and logwood.

*Ivory on Woolen Cloth.*—For two pieces of 42 lb. A bath is made of 2 lb. alum, 2 lb. tartar, 1 oz. indigo carmine, and 2 oz. madder, in which the cloth is boiled for one hour.

*Silver Gray for 20 lb. Half Woolen Cloth.*—After having been well cleaned, a bath is formed of 2 oz. tannin dissolved in hot water, the cloth introduced in this and turned for one hour, and then darkened in a fresh bath with 1 lb. nitrate of iron until the desired shade is obtained.

*Dyeing of Jute Yarn.*—Dark green for 10 lb. yarn. Prepare a hot bath with 1 lb. extract of quercitron and 1 lb. alum: soak the jute for an hour in this, take out, rinse, and pass through the two following baths. First bath—10 oz. nitrate of iron and 2 oz. tin salt; after ten turns take out, wring, and pass into the second bath of 5 oz. yellow prussiate and 3 oz. red prussiate; give ten turns, take out, and add 5 oz. sulphuric acid; after ten turns in this bath, take out and wring. Red for 10 lb. bleached yarn: Mordant for an hour hot with 7 oz. tannin, wring, and place in a bath of phosphine; it is of the greatest importance only to employ the very best quality of the latter if a bright red is to be produced; ⅓ oz. of phosphine will be found sufficient for 10 lb. of yarn; lastly, the yarn is passed through boiling water in which a little saffranine is dissolved. Yellow for 10 lb. bleached yarn: Place the yarn into a cold bath of 3 oz. acetate of lead, give ten turns, take out, and wring, and pass into a bath of 3 oz. bichromate of potash, where it is left until the desired shade is obtained; to have a dark shade it is necessary to increase the quantity of acetate of lead and of the bichromate, and to give it a reddish shade the yarn is afterwards passed through a weak bath of saffranine.

## DISTILLATION OF COAL TAR.

THE name tar is generally applied to oily bodies, partly heavier and partly lighter than water, formed by the dry distillation of organic matter, and differing in its composition according to the different nature of the raw material employed.

We may consider tars as natural or artificial, understanding by the former the tarry matter formed from primeval vegetable remains by subterranean heat, and the enormous pressure of the superincumbent strata, of which petroleum is a rectification product.

Artificial tars may be distinguished as wood tar, peat tar, lignite tar, and coal tar. The last mentioned being our especial subject, we shall treat of the former in so far only as the characteristic distillation products of these tars differ from those of coal tar. We must not forget how it has been proved by Letny, Atterberg, and others, that wood tar, petroleum tar, etc., if passed through ignited tubes, yield the same distillation products as coal tar—a fact of the greatest importance for the color trade, if, as we can scarcely doubt, the returns are as good on the large scale as in laboratory experiments.

Wood tar consists almost exclusively of the same substances as coal tar; but whilst phenol and cresol predominate in the latter, the main constituents of the former are guaiacol and creosol, monomethylic ethers of pyrocatechin or of homopyrocatechin.

Peat and lignite tars on distillation yield, as characteristic products, photogen, solar oil, and paraffine, hydrocarbons belonging chiefly to the fatty series, whilst the hydro-

carbons of coal tar belong principally to the aromatic series.

Coal tar is as old as the manufacture of coal gas itself, though in the beginning its valuable utilizations were not thought of. The tar was, indeed, used to some extent for coating wood and for the preparation of soot-black. About 1840 the distillation of tar was first attempted, the so-called creosote oils only being collected and used for the saturation of wood, especially railway sleepers, whilst the other products of distillation were overlooked. The distillation of tar underwent a change after the discovery of the aniline colors. The process was conducted so that the oils containing benzol and toluol were collected, together with the creosote oils, whilst soft pitch remained in the retorts. Subsequently, when large quantities of anthracene were wanted for the manufacture of alizarine, the distillation was pushed further, so that hard pitch remained. A wide field for research still remains, and many substances found along with benzol and anthracene still await a useful application.

Coal tar is a thick, black, oily mass; its specific gravity lies between 1·120 and 1·150; insoluble in water, of which, however, it contains a considerable quantity in a state of mechanical admixture. When submitted to dry distillation it yields a great number of bodies, neutral, alkaline, and acid. As a representative of the first class it is common to mention naphthaline; of the second, aniline; and of the third, phenol (carbolic acid), which, however, accurately speaking, is no acid at all.

As regards the origin of the tar, an investigation of Magnus is of great interest. He succeeded, on passing olefiant gas through ignited tubes, in obtaining a tar closely resembling coal tar, and which, on destructive distillation, yielded naphthaline in abundance.

The process of the distillation has been so often and so fully described that it requires but brief mention here, except as regards the treatment of the anthracene oils, of which little has been hitherto made known.

After the retort has been charged with tar, the fire is kindled, and a moderate heat is applied at first to prevent boiling over, in consequence of the formation of watery vapor. After about twelve hours all the water is expelled, which may be known by the cessation of the rattling noise.

The water which first passes over carries with it a little of the light oil; it is, therefore, collected separately, the oil is drawn off, and the water is worked up for ammoniacal salts. After the water is expelled, the fire is strengthened. The light oils and then the heavy oils are collected in separate receivers. The presence of naphthaline is easily detected by letting a few drops of the product fall upon a piece of cold iron; if naphthaline is present they congeal to a yellow, butter-like mass. The receiver for heavy oils is then closed, and that for creosote oils opened. The napthaline, which at first is abundant, disappears again, and creosote oils, which boil at a higher temperature, predominate. After a time the oils, on cooling, become thicker, and finally congeal again, not, however, owing to naphthaline, but to anthracene and phenanthrene. The air is now pumped out from the retort, and as soon as vapors pass over which do not condense to a paste, the fire is withdrawn, the air pump is disconnected, dry steam is turned into the retort, and the pitch run off into an air-tight cooling tank. The whole operation lasts thirty-six hours.

The anthracene oils (green oils) are pumped up from the receivers into a special reservoir, where they become perfectly cold. They form then a greenish-yellow buttery mass, mixed with soft crystalline grains. This is submitted to filtration, either in a filter press or other suitable appliance. The oils which run off are added to the creosote oils, and serve for preserving timber. The crude anthracene thus obtained forms a brownish-green friable mass, containing about 12 per cent. of real anthracene. It is then submitted to hydraulic pressure between heated plates, and is thus obtained in hard, firm, yellowish-green cakes, which in summer contain 20 to 33 of real anthracene, but in winter only 23 to 25. Sometimes it occurs as low as 18 to 20 per cent. It is next ground up, mixed with an equal weight of solvent naphtha, heated gently, filtered, submitted to hydraulic pressure, and sublimated in superheated steam. It then forms a white impalpable powder, containing 50 to 60 per cent. of real anthracene.

The naphtha, which has served to wash the anthracene, is distilled, and the fixed residue yields a lamp black, admirably adapted for printer's ink.

The yield of benzol is about 1·1 per cent. on the gross weight of the charge; solvent naphtha, 1·0; burning naphtha, 1·4; creosote oils, 35; anthracene, at 30 per cent., 1·0; and pitch, 58·6. These figures vary with the quality of the coal; that of Boghead gave especially toluol and naphthaline; cannel yields much benzol and anthracene, but little naphthaline. The coals used at the Toulouse gasworks yield a tar very rich in anthracene.—*Chemical Review*.

## MANUFACTURE OF POTASH AND OF CHLORIDE OF METHYL FROM THE DREGS OF "TREACLE."

By M. CAMILLE VINCENT.

THE dregs here referred to are the residues from the stills in which rum or closely analogous spirits are obtained by the distillation of treacle. When all the spirit has been drawn off, there remains a thick muddy refuse which has hitherto been wasted, and which has in some places even occasioned no small nuisance. The author's experiments refer more immediately to the treacle obtained on refining beetroot sugar —an article much inferior to the treacle from cane sugar, and scarcely fit to be used as an article of food. As, however, a large quantity of rum is prepared from the treacles and the waste liquors of the cane-sugar manufacture, the process deserves attention in Britain, and in our sugar-producing colonies.

We have already had occasion to draw the attention of our readers to the chloride of methyl, and its industrial applications, the more as it may be made to play an important part in the manufacture of certain aniline colors.

In France the consumption of potash is far from being met by the native production, whence large quantities have been annually imported. One of the most important sources may be found in the treatment of the dregs of beetroot treacle.

Here, however, we must point out that all methods of obtaining potash from vegetable and animal matter, *e. g.*, from the dregs of treacle, the ashes of wood, or the grease of wool, are in the long run merely robbing Peter to pay Paul. The plant derives its potash from the soil, where it is not to be found in an unlimited and inexhaustible quantity, and as this potash is necessary for the growth of plants, if we do not return it to the soil our lands will ultimately become incapable of producing crops. Hence it is a great misfortune that potash should be used in manufactures, especially as a mere vehicle for some other agent, as is the case in tartar, chrome, the prussiates, potash alum, and soft soaps. It is still more to be lamented, however, that refuse containing potash should be poured into the rivers.

The ordinary method of treating treacle dregs consists in evaporating them to dryness in open pans, and calcining the residue. In this manner all the organic substances present are necessarily wasted. M. Vincent's improvements consist in submitting the dregs to dry distillation in iron cylinders, like gas retorts, when a variety of products can be obtained.

There is firstly a light and very porous charcoal, containing all the mineral matters of the dregs, the potash, etc., which are easily withdrawn by lixiviation. The remaining charcoal is then remarkable for its great purity, and especially for its freedom from sulphur compounds.

The second product is a watery liquid, with a small quantity of tar, which is deposited in recipients similar to those employed in gas works for the collection of the ammoniacal liquor. The tar contains a little phenol and bases belonging to the chinoline series, but neither benzol nor toluol. The water contains ammonia in the states of carbonate, hydrosulphate, and cyanide, sulphuret of methyl, methylic alcohol, trimethylamine, formic acid, and other monobasic fatty acids.

There is also formation of gases—carbonic acid, carbonic oxide, hydrogen, and carbureted hydrogen. It is proposed to use the carbonic acid in purifying the potash from sulphur compounds.

The condensed water stands at about 5° Baumé, and yields per 220 lb. treacle the following products:

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|---|---|
| Sulphate of ammonia | 4 lb. 6 oz. |
| Pure methylic alcohol | 52 fluid oz. |
| Crude salts of trimethylamine | 15 gr. |

The firm of Tilloy, Delaune & Co., of Courrières, obtain by this process yearly upwards of a million pounds sulphate of ammonia, and 65,000 lb. of methylic alcohol.

M. Vincent has further succeeded in decomposing the trimethylamine hitherto useless, so as to yield ammonia and chloride of methyl.

The water containing the crude salts of trimethylamine is evaporated, till its boiling point rises to about 500° Fahr. At this heat there is a brisk escape of gas, consisting of trimethylamine and chloride of methyl.

The residue is composed of chloride of trimethylamine, and of monomethylamine. When the heat reaches 581° Fahr. nothing remains in the still but sal-ammoniac and chloride of monomethylamine. The escaping gases contain, besides chloride of methyl, a large proportion of ammonia. At 617° Fahr. the entire mass is decomposed, and converted into a mixture of ammonia, trimethylamine, and chloride of methyl. This gaseous mixture is passed into common muriatic acid, which retains the ammonia and the trimethylamine. The chloride of methyl passes on, and is washed in alkaline water, and collected in a gasometer over water. The muriatic solution of the two bases is heated till it boils, and let stand in a cold place. Sal-ammoniac crystallizes out, and is dried in a centrifugal. The mother liquors, containing trimethylamine, are returned to undergo dry distillation again, along with fresh lots of the original salt of trimethylamine.

The chloride of methyl is dried, liquefied by pressure, and preserved in strong metal cylinders. It costs at present 3s. 4d. per 35 oz. It is chiefly employed in the production of artificial cold, and in the manufacture of coal-tar colors. Here it supersedes the bromide, iodide, and nitrate of methyl, being much cheaper than the two former, and free from the dangerously explosive character of the last.—*Chemical Review*.

## CERIUM ANILINE BLACK.

By H. BUHRIG.

As far back as 1874 Kruis drew attention to cerium aniline black as one of the finest and fastest aniline blacks. Hitherto the suggestion has not met with practical application in the trade, because the price of cerium compounds was much higher than that of the chloride and sulphuret of copper, and even than the salts of vanadium, which must be pronounced cheap if their great efficacy is taken into account, and also because no one took up the idea of preparing a salt of cerium at a price suitable for printing. This difficulty is now surmounted, and every calico printer may prepare the cerium compounds necessary for his own use with but little trouble and expense. Hence we may now expect to see cerium black make its way and prove a dangerous rival even to the vanadium black. At the print-works of J. Lytsche, at Petersburg, cerium aniline blacks have been successfully printed for more than a year. The cerium compound used is the sulphate of cerous oxide, prepared by dissolving in sulphuric acid the cerite which is obtained in large masses from Riddarhytta, in Westermannia, Sweden. This mineral consists of

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|---|---|
| Silica | 20 |
| Cerous oxide | 60 |
| Lanthania and didymia | 8 |
| Water, with traces of iron, lime, and copper | 12 |
| | 100 |

After treating the cerite with sulphuric acid the mass is lixiviated with water, and the liquid is filtered to remove silica. The liquid thus obtained is ready for use. As cerite does not dissolve very easily, it should be ground to a very fine powder. M. Bührig dissolves the mineral in leaden pans, taking the following proportions: 1 lb. powdered cerite is mixed with 1 lb. oil of vitriol to a thick paste, and allowed to stand on the sand bath for some hours, being frequently stirred. The mass swells up; and a part of the acid evaporates, whilst a light gray solid body remains.

This is again ground and mixed up with 4 or 5 oz. more oil of vitriol, and allowed to stand for some days in a warm place. It is then heated again for several hours, and the excess of sulphuric acid is completely driven off. The whole is then carefully extracted with water, being ground to powder, and thrown in small portions at a time into cold water, to which some ice may be usefully added. The reason for this is that much heat is produced as the salt dissolves, and, if the water becomes warm, the powder clots together, and can then be lixiviated only with much difficulty. In the course of a couple of days the water has become saturated; it is drawn off and fresh water is poured upon the sediment till all the soluble matter is taken up.

One pound of cerite yields about 9 lb. of solution, which may be at once used for the black color. The author has ascertained experimentally that the compounds of lanthanum and didymium, which, of course, coexist with cerium in this solution, have no injurious influence, so that the tedious and delicate task of their separation need not be attempted.

For printing, the color is mixed as follows:

| | | |
|---|---|---|
| White starch | 30 lb. | 10 oz. |
| Light calcined starch | 14 lb. | 4 oz. |
| Water | 242 lb. | |
| Sal ammoniac | 3 lb. | 14 oz. |
| Chlorate of potash | 6 lb. | 12½ oz. |
| Muriate of aniline | 13 lb. | 7¼ oz. |

And a little of the solution of cerium. To 220 lb. of color may be taken 49½ fluid oz. of the solution, equal to 1¾ oz. oxide of cerium. Eight hours are required for the development of the color. If salt of vanadium is used, an equally deep black is obtained with the same ingredients, if to 220 lb. of color we take 20·33, or say 2·3, of a fluid ounce of a solution of vanadium, containing 2·25 of 15 grains of actual vanadic acid (say, 1 1-10 grain).

The cerium black is distinguished by a rich, deep, blue-black reflection, which cannot be obtained even by using extra quantities of vanadium. The cerium aniline gray is also finer than the corresponding vanadium shade. It is mixed as follows:

| | | |
|---|---|---|
| White starch | 18 lb. | 12¾ oz. |
| Light calcined starch | 4 lb. | 2 oz. |
| Water | 132 lb. | |
| Sal ammoniac | 1 lb. | 1¼ oz. |
| Muriate of aniline | 1 lb. | 1¼ oz. |
| Muriatic acid | 1 lb. | 1¼ oz. |
| Cerite solution | | 5¾ oz. |

The gray is developed in a few hours in a warm aging room, and requires no passage through soda, but merely a good soaping. It may be printed along with steam colors, as it does not attack the fibre, though its beauty is injured. It resists the greening action of sulphurous acid better than the vanadium black.—*Dingler's Polyt. Journal*.

## RECENT CHEMICAL INVENTIONS.

*Manufacture of Sulphuric Acid.*—W. J. Blinkhorn prepares a solution of nitrate of soda at 70° Tw., and causes it to flow in fine, regular streams upon sulphuric acid in a vessel heated by the kiln vapors. The nitrous fumes given off are passed into the chambers, to come in contact with the sulphurous acid.

*Lubricating Oil.*—P. Huth, of Wormlitz, obtains an oil which is not decomposed even at the highest pressure of steam. He dissolves oleate of alumina in those hydrocarbons which have the highest boiling points. The oleate of alumina is obtained by decomposing sulphate of alumina with liquid soap.

D. Felton, of Manchester, prepares a waterproof paper by a kind of padding in a mixture of three parts sulphate of zinc and two parts ammonia at 0·875.

Fr. Graessler, of Canstatt, prepares yellow coloring matters as follows, from sulphamidoazobenzolic acid and its homologues. He remarks that the yellow salts of amidoazobenzol and of amidoazotoluol have hitherto met with no practical application in dyeing, on account of their want of permanence. The conjugated sulpho-acids of these bases yield, however, permanent yellow dyes. They are prepared by the action of from three to five parts of fuming oil of vitriol upon one part of an amidoazo salt (especially amidoazobenzol) at ordinary temperatures, or at a heat not exceeding 212° F. The product is washed, the excess of acid neutralized, dissolved in alkali, and concentrated. By amidoazobenzol the inventor understands the compound formed by the action of nitrous acid or of nitrites upon salts of aniline, and is capable of forming salts with acids, in contradistinction to diazoamidobenzol, which does not combine with acids, but is destroyed by them. Sulphoamidoazobenzolic acid gives canary yellows, and sulphoamidoazotoluolic acid shades, verging upon orange. The colors are dyed in a slightly acid bath.

The Berlin aniline company prepare colors by the action of benzotrichloride upon aromatic tertiary amines and phenols. Whilst dimethylaniline and the aromatic tertiary monamines yield green dyes, yellows, reds, and browns are obtained from the phenols and benzotrichloride. Resorcine yields a product resembling fluoresceine.

Dr. G. H. E. Bering, of Bombay, proposes to obtain a new glaze for paper hangings, useful also as a thickening agent in textile printing, from a compound of caseine with the tungstate of soda. The curd of milk, separated from the whey and rendered as dry as possible by pressure, is ground down to a coarse but uniform powder by being passed between rollers moving in opposite directions. This powder is then ground up with a solution of one part tungstate of soda in one part of water, or the mixture of curd and solution of tungstate of soda is passed through the above-mentioned rollers, which crush the particles. As soon as the tungstate of soda is brought in contact with the perfectly dry curd the reaction begins, and the mass grows constantly tougher. If the sample of curd contains too much buttermilk, it is first stirred up with a little muriatic acid and water, which is repeatedly diluted with water till the acid reaction disappears, when it is pressed again, and treated as above directed. The cold mixture of tungstate of soda and curd is placed in a pan and warmed with steam heat or in the water-bath, adding a very little water if the mass was too dry, and heated gently with constant stirring, till the sample taken out shows no granules of curd. To prevent putrefaction a little carbolic acid and oil of cloves may be added. When the mass is perfectly homogeneous it is poured out, and on cooling becomes an almost solid mass. This "glutine," as the inventor calls it, is soluble in water in every proportion, and has a very great adhesive power. It is particularly adapted for attaching paper labels, etc., to metals, glass, and porcelain. When once dry it is not easily redissolved in water. It forms a fine shining glaze for paper hangings printed with earthy and metallic colors, and which can be made more flexible by the addition of a little glycerine. Glutine dissolves also in glycerine, forming an adhesive mass, which, if applied on paper, forms a flexible coating. If taken through alum water when dry it assumes some of the characters of leather. On account of the proportion of tungstic acid present it yields the most various shades with the decoctions of the woods. Thus, if cotton or linen is first steeped in a solution of glutine, dried, and then taken through decoction of logwood, a violet shade is produced. If the cloth after treatment with glutine and drying is passed through acids or solutions of mineral salts, a variety of fast dyes are obtained.—*Chemiker Zeitung*.

[It will doubtless be known to some of our readers that curd, carefully freed from fatty matter, and redissolved in alkaline liquids, has been recommended and used many years ago as a cement, glaze, etc. Among the liquids employed for dissolving the caseine, according to the particular purpose in view, we may mention ammonia, borax, lime water, phosphate of soda, etc. We have never seen tung state of soda previously recommended, but we are far from sure that it is any improvement. As a thickener in calico printing, we think the use of glutine will be somewhat restricted from the very fact mentioned that it acts upon the colors which may be present.—ED. *Chemical Review.*]

Barrow, of Clayton, proposes the following improvements in the production of ammoniacal salts: He employs earthy basic substances in combination with sulphur, in order to separate ammonia from its combinations with acids, chlorine, etc., to recover the sulphur and to obtain carbonates from their earths. Such earthy basic substances in combination with sulphur are found in the waste lime from gas purifiers. Crude ammoniacal liquor is mixed with such gas lime, or sulphuret of calcium, in such proportions as to produce complete decomposition. By subsequent distillation the volatile compounds of ammonia and the sulphur are separated from the non-volatile acid, or chlorine compounds of the basic earths present. The volatile compounds of ammonia are passed into sulphuric or muriatic acid, forming the corresponding salts, whilst the sulphureted hydrogen is converted into sulphurous acid (which may be utilized in the chambers) by ignition or combustion in contact with atmospheric air or oxygen. The non-volatile compounds consist chiefly of carbonate of lime, which may be reburnt and used again in the purifiers. If sulphuret of calcium is employed, as obtained by heating oxide of iron from the gas purifiers with milk of lime, the sulphuret is separated by washing from the insoluble oxide, using the sulphuret with ammoniacal liquor, as above, and drying the oxide of iron in small quantities, so that it may again be fit for use in the purifiers. The gases evolved contain other compounds as well as sulphureted hydrogen; these are removed by passage through an oil scrubber, in which drops of oil meet the stream of gases, and absorb the sulphuret of carbon. A subsequent distillation separates the sulphuret of carbon from the oil.

*Utilization of Caoutchouc Oil, obtained from Old India rubber Wares.*—Danckwerth & Koehler, of Petersburg, prepare this oil by submitting waste India rubber to dry distillation over an open fire, with the aid of superheated steam. A product is thus obtained which, when inspissated and galvanized, possesses in the highest degree the properties of good natural caoutchouc. The lighter oils, which serve for the preparation of varnish, are separated from the heavier ones, which are mixed with hemp or linseed oil, and boiled down.

Dupuis, of Paris, proposes to improve goods dyed in the vat by the application of a dry stove heat, or of steam, or superheated steam. The shade, and sometimes the intensity of the color, is often decidedly modified, though it does not appear in what direction. He prefers hot air for wool, and steam for cotton and other vegetable fibers. The temperature of the air or steam may be from 212° F. to 302° F., and the time of exposure is from half an hour to two hours, or upwards.

J. Nathansohn, of Berlin, has patented the following process for coating silk yarns with metals: The yarns, when dyed in the usual manner, are steeped in a cold solution obtained by dissolving half a pound of gelatine in ten gallons of boiling water. They are next steeped in a similar solution, to which bronze powder of any desired color has been added. After being wrung and dried they are taken through a solution of wax in benzine and dried again.—*Chemical Review.*

## PURIFICATION OF MERCURY.

PROF. LOTHAR MEYER purifies mercury by means of a moderately dilute solution of commercial crystallized ferric chloride, in the apparatus shown in the cut. The mercury flows from the stoppered tube, A, in a very fine stream into the tube, B, which is 3 to 4½ feet long, of a diameter of about


1½ inches, and is filled with a solution of ferric chloride. The tube stands in a vessel, C, containing mercury. This vessel must be at least $\frac{1}{15}$, or better $\frac{1}{10}$ as high as the tube, B, so that it may contain sufficient mercury to balance the column of ferric chloride solution. The cylindrical vessel, C, is provided with a lateral tube. If the mercury which is to be purified is very impure, it is first filtered through a filter, perforated with a pinhole, into the tube A. From there it is allowed to fall in very fine drops into the solution of ferric chloride, and after traversing the latter, arrives at the bottom in minute drops, which do not at once coalesce, as they are covered by a thin coat of chloride or subchloride. But the pressure of the succeeding globules forces them gradually below the edge of the tube, B, into the cylindrical vessel, C, whereby at the same time the thin incrustation of the globules is left behind, so that only pure brilliant mercury flows over into the receptacle, D. Occasionally it may be necessary to repeat the operation.—*Ber. d. Deutsch. Chem. Ges.*

## A NEW COMPOUND OF SILICIUM AND STRONTIUM.

DR. SCHUCHARDT in Gorlitz has obtained a compound of silicium and strontium, in form of a gray powder, having a weak smell similar to that of phosphureted hydrogen. Treated with diluted muriatic acid it generates gaseous silicated hydrogen, which ignites spontaneously on coming in contact with the air. This new compound is undoubtedly the best preparation for making larger quantities of silicated hydrogen.—*Chemiker Zeitung.*

## EFFECTS OF SUPEROXIDE OF HYDROGEN ON IODIDE OF POTASSIUM.

IN direct opposition to the views entertained by the greater number of chemists, Schöne found that perfectly pure superoxide of manganese separates iodine from potassium iodide, caustic potassa being formed. This reaction is at the same time accompanied by the generation of a quantity of oxygen, the iodide decomposing, by catalytic force, the superoxide, $H_2O_2$, into $H_2O$ and O. The iodide itself is decomposed only to a limited extent. Nevertheless, this partial decomposition proves that the ozonoscopic observations made with Schönbein's potassic iodide starch paper, as well as those made with Houzeau's prepared red iodic litmus paper, are no absolute proof of the existence or the quantity of ozone in the air.—*Annalen der Chemie.*

## ALUMINUM ALCOHOLS.

GLADSTONE and Tribe succeeded some time ago in obtaining, by treating alcohol with aluminum and iodine, an ethyl compound of aluminum. They have now obtained similar compounds with methylic, amylic, and butylic alcohol. Butylo-aluminic alcohol has the formula $Al_2(C_4H_9O)_6$; the former compounds have not yet been obtained perfectly pure.—*Bericht. der Chem. Gesell.*

## ON THE PRODUCTS OF OXIDATION OF VOLATILE NITRO-PHENOL OXIDE.

MR. M. GOLDSTEIN has subjected oxidized volatile nitrophenol to the effects of heat and different reagents with the following results:

The metallic compounds of that substance are all amorphous; the compounds with potassium and sodium are nearly soluble in water and alcohol. On allowing the solutions to evaporate spontaneously, these compounds are deposited slowly in form of reddish amorphous masses. On heating the oxide with chloride of benzoyl a body is formed having the formula $C_{12}H_6(NO_2)_2(C_7H_5O_2)_2$, which crystallizes in colorless needles, appearing under the microscope as elongated rhombic plates. It is insoluble in water, sparingly soluble in cold, more readily soluble in boiling alcohol, but easily soluble in benzole. It melts at 376° F., and solidifies again on being cooled down to 358°. From the property of the oxide of nitro-phenol, in forming dibenzoates with chloride of benzoyl, the author assumes its formula to be as follows: HO $(O_2N)\,H_3C_6—C_6H_3\,(NO_2)$ OH. The author has not yet succeeded in obtaining the non-volatile oxide of nitrophenol.—*Ber. der Chem. Gesellsch.*

## ELECTRO-MAGNETS.*

AN electro-magnet, of the form usually met with in ordinary electrical apparatus, is as simple as a spool of thread, which it very much resembles; but there are connected with it questions which seem to baffle the tyro, and which are really puzzling, unless the principles which underlie its construction and operation are thoroughly understood.

The electro-magnet is composed of a magnetic core, or cylinder of iron; a helix, which consists of an insulated conductor, wound upon a bobbin and surrounding the core, and an armature, a piece of iron, usually of prismatic form, placed transversely in front of the ends of the core, which ends are termed the poles of the electro-magnet.

If the core is composed of a straight piece of iron the magnet is termed a bar-magnet, and usually acts by one of its poles only; but if the core is bent in such a manner that both its extremities may act on the same armature, it is termed a horseshoe or U-magnet. The same result that is secured by bending the bar may be obtained by uniting several pieces together. The construction of a form in common use is shown in Fig 3, next page.

The polarity of an electro-magnet depends upon the direction in which the helix is traversed by the electrical current. In speaking of the direction of the current, the positive current, *i. e.*, that which proceeds from the copper or carbon element of the battery, is always meant.†

If, when looking at the end of a magnet, the helix appears to be wound in a right-handed direction, or in a direction corresponding with that of a right-handed screw thread, and if the current traverses it in a right-hand direction, *i. e.*, in a direction corresponding with the motion of the hands of a watch, then the end of the bar inclosed by the helix, which is nearest the observer, will be south, the end farthest from the observer will be north. If the helix is wound in the opposite direction, the reverse of what has just been described will result. Fig. 1 shows a right-handed or dextrorsal helix. Fig. 2 shows a left-handed or sinistrorsal helix. After what has already been said, little explanation will be required to render the method of winding an electro-magnet clear.

The two cylindrical cores, A B, of the U-magnet, shown in Fig. 1, may be considered as a bar magnet, wound left-handed, as shown in Fig. 2, cut in two and placed in the position shown in Fig. 3. The current entering the helix of B, as indicated by the arrow, produces N polarity in the outer end of the core, B; and although the core, A, is wound in precisely the same manner as the core, B, the current enters the helix at the inner end and traverses it toward the outer end in the opposite direction, producing S polarity in the core, A. The same result might be secured by carrying the wire from the inner end of the core, B, to the outer end of the core, A, and winding the latter in a right-handed direction; but, for obvious reasons, the method illustrated is the one followed out in practice.

Fig. 3 shows a U-magnet, made up of the helixes—the cores, A B, the yoke, C, and the two iron screws that enter the ends of the cores and bind them firmly to the yoke. One advantage in this kind of magnet is that the wire may be wound directly on the cores, and the magnet is more compact than other forms. The core of the magnet, shown in Fig. 4, consists of a single piece of soft bar iron bent into a U-form. The helixes are wound separately and slipped over the poles, and afterward connected at their inner ends. Helixes of this sort are commonly wound on a separable spool covered upon the inside with paper, and the several coils are cemented together with sealing wax or glue.

To obtain the best results the diameter and length of the wire on a magnet must be adapted to the circumstances under which the magnet is used. For example, with a short circuit and battery having small resistance, a heavy and not very long wire should be used. When the circuit is long, or includes considerable resistance, the wire must be smaller and longer to render the resistance of the magnet equal to that of the rest of the line.

In a telegraph sounder operated by a local battery, or in a call-bell used on a short wire, the helices are wound with No. 24 insulated copper wire, and have a resistance of about 4 ohms. For sounders intended for direct working, the helices are wound with No. 24 to No. 32, and even 36, Birmingham gauge, according to the length and resistance of the circuit in which they are intended to be used.

A receiving magnet or relay has two soft iron cores, each 2 inches long and 11-32 inch diameter, which are screwed to a soft iron yoke 2 inches long and ¼ inch thick. The helices are wound with about 1,820 feet of No. 32 insulated copper wire (0·009 inch in diameter) to a diameter of 1·25 inches. The average number of convolutions is 8,500 and the resistance 150 ohms.

In winding electro-magnets used in telegraphy it is found that the distance from the iron core to the outer side of the helix should not exceed about one-half inch. When the distance exceeds this limit the proportional effect of the current upon the iron core rapidly decreases; for this reason, when it is desired to increase the number of convolutions the only resource is to reduce the sectional area of the conducting wire.

As the magnetism which a magnetizing spiral produces in an electro-magnet is proportional to the strength of the current and to the number of convolutions (when the distance between the wire and iron core does not exceed a certain limit, as before observed), it is not difficult to determine under what conditions a magnetizing helix will produce the greatest magnetic force, provided the strength of the current and the resistance are known. For example, let the resistance of a wire that makes but a single convolution around the iron core—but that occupies the entire space intended for the coil—be indicated by $u$. If we divide the wire so that it will make two convolutions instead of one, its sectional area will be only one-half as much, and its strength is doubled: therefore the resistance of the wire is four times as great as it was at first, and will be $4u$.* In the same way, when the original wire is made into $n$ convolutions instead of two, the total resistance, $r$, of the coil is

$$r = n^2 u.$$

Now, if E denotes the electro-motive force of the battery, W, the resistance of the battery and the wire, and therefore the whole resistance outside of the coil, it is found that the strength of the current, S, according to Ohm's law, is

$$S = \frac{E}{W + n^2 u}.$$

Consequently the magnetic force is

$$M = n\,S = \frac{n\,E}{W + n^2 u}.$$

By varying $n$ the magnetic force, M, of the electro-magnet also varies, and M attains its greatest value when the denominator is the smallest; the latter, for theoretical reasons, is the case when, in the preceding equation,

$$W = n^2 u \ldots\ldots\ldots\ldots (1),$$

or

$$W = r.$$

The magnetizing coils of an electro-magnet therefore act most powerfully when their resistance ($r$) is equal to the total resistance (W) of the circuit outside of the coils.

If we indicate by $l\ q\ s$, respectively, the length, sectional area, and specific resistance of the wire which surrounds the iron core, then the resistance, $r$, of the coil, is

$$r = \frac{l\,s}{q}.$$

Hence the action of the coil is a maximum when

$$W = \frac{l\,s}{q}.$$

As only copper wire, whose specific resistance = 1, is employed for wire coils, we find that for the maximum of magnetic intensity—

$$W = \frac{l}{q} \ldots\ldots\ldots (2).$$

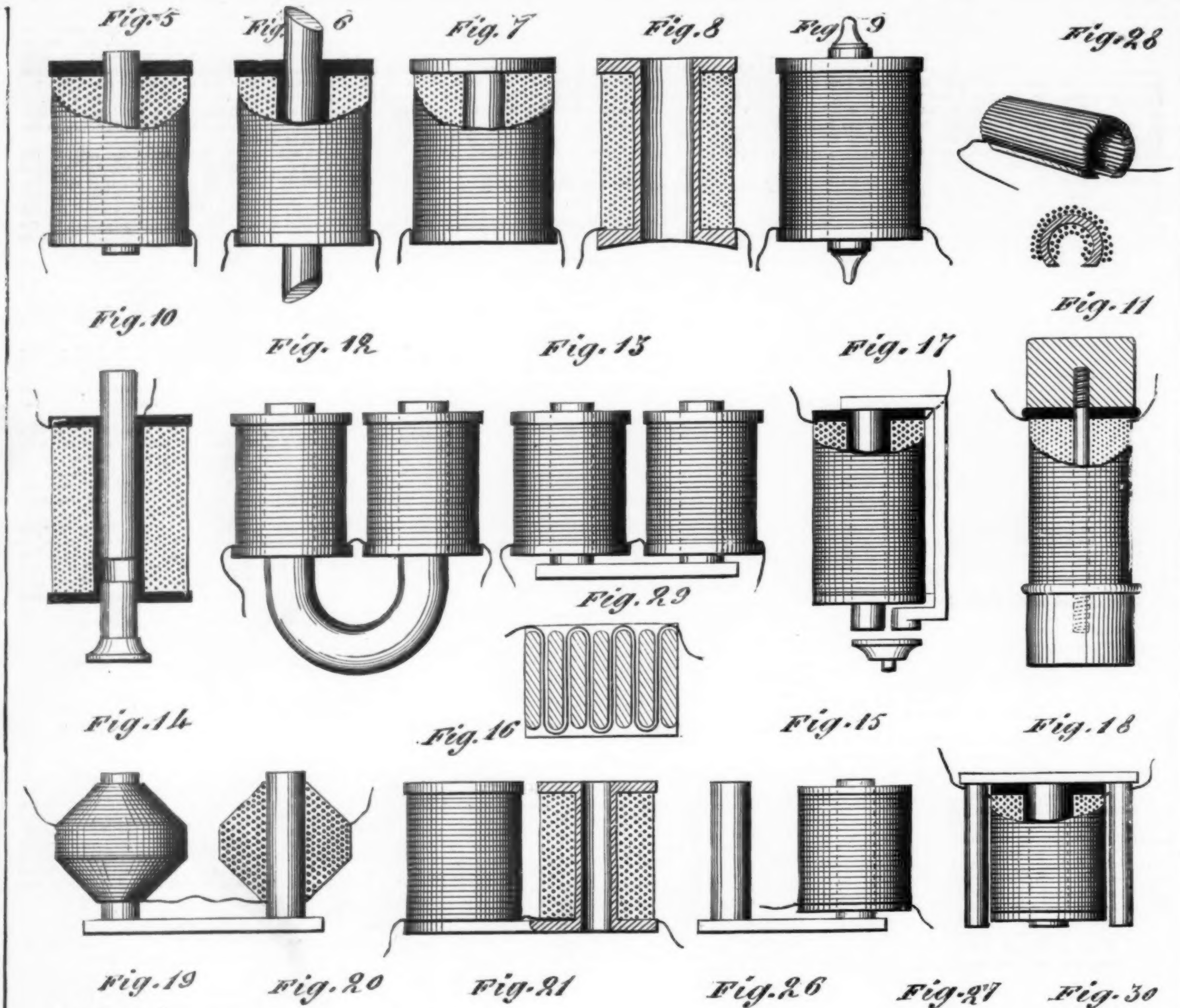
If we take into consideration the fact that the diameter of the coil should not exceed a certain limit when its magnetizing power is not otherwise restricted, equation 2 gives these conclusions:

1. When the resistance, W, outside of the coil, is very large, the proportion $\frac{l}{q}$ should also be large; the coil should be made of wire of great length and small sectional area, or very long and fine wire.

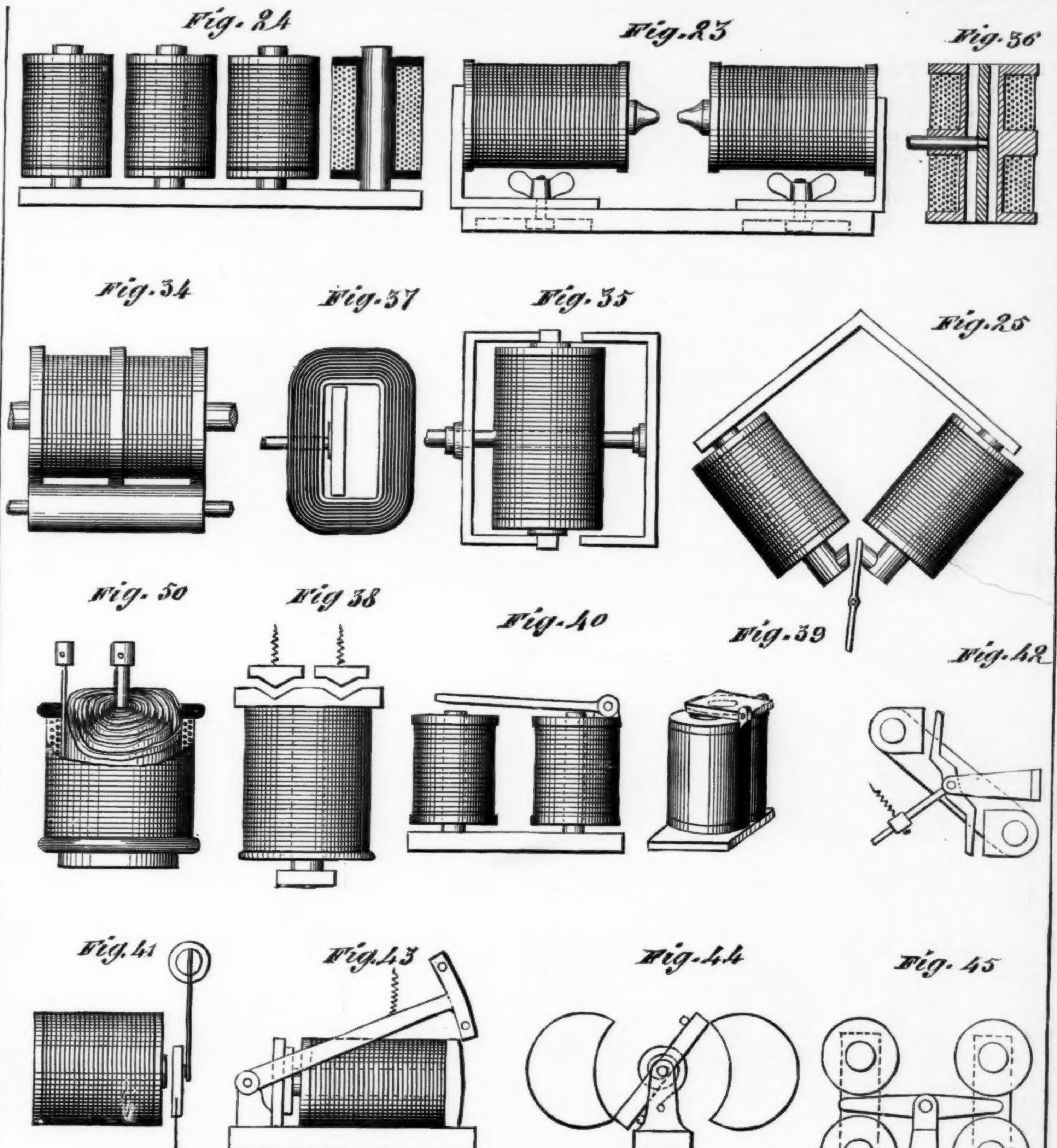
* For many of the illustrations, as well as for much of the matter contained in this article, we are indebted to "The Speaking Telephone, Electric Light, and Other Recent Electrical Inventions," by George B. Prescott; also to "Electricity and the Electric Telegraph," by the same author.

† The copper or carbon plate in a battery is negative; the zinc plate is positive. The positive current proceeds from the negative plate, and the negative current from the positive plate. The positive electrode is connected with the negative plate, and the negative electrode with the positive plate.

* The electrical resistance of a metallic wire is directly in proportion to its length, and inversely in proportion to its sectional area, or the square of its diameter.




FORMS OF ELECTRO-MAGNETS.




FORMS OF ELECTRO-MAGNETS.

2. When the resistance, W, outside the coil, is small, then the proportion $\frac{l}{g}$ ought to be small also; in this case a short and thick wire should be used.

The former applies more directly to coils of electro-magnets used on long telegraph lines, or in circuits where the battery has a great resistance. The latter applies in cases where electro-magnets are operated by a local battery of small resistance.

Experiment has proved that a mass of soft iron is susceptible of a maximum of magnetization only; but this is more than five times as great as that which a corresponding mass of hardened steel will retain. The attractive force exerted by an electro-magnet upon its armature is proportional to the diameter of the core and to the square root of its length.

The maximum of force, of which an electro magnetic system, composed of a helix, core, and armature, is capable, is developed when the dimensions of the two latter in respect to their length and surface are equal.

In regard to the proper proportion of the cores and yoke of an electro-magnet, it may be stated that the yoke should be equal in length to one of the cores.

When it is desired to realize the greatest amount of force from an electro-magnet the mass of the armature should be considerable; but when the utmost rapidity of motion is required the mass of the armature should be as small as possible. In respect to force alone, the armatures ought always to be a little broader than the poles which act upon them, and their length ought to somewhat exceed the polar extremities of the magnets, and their thickness should vary according to the force of the magnet.

The accompanying plates show the various forms of electro-magnets generally used for electrical purposes. Figs. 5, 6, 7, 8, 9, 10, and 11, are electro-magnets, whose poles are straight, beveled, tapering or flattened, according to the purpose needed. In Fig. 7, the copper disks or end pieces are soldered to the core of the electro-magnet. In Fig. 8, the core is hollow, with two iron disks at the extreme ends to increase the polar surfaces, and to serve as end pieces for the bobbins. Fig. 10 represents Bonelli's electro-magnet, in which the armature forms a part of the magnetization, and makes the attraction between the two parts more powerful.

Fig. 11 represents an electro-magnet provided at both ends with two iron pallets. This plan is used to advantage as an armature of an electro-magnet, in which case the pallets correspond to the poles of the electro-magnet. This arrangement has been adopted by Mr. Maroni, for the Italian Morse instruments. Figs. 12, 13, 14, 15, 16, 17, 22, 23, and 25, show the various forms which have been given to the double branched electro-magnets. Fig. 13 represents the best known and more generally used form. Fig. 14 shows an electro-magnet in which the helix is wound around the iron core without retaining disks at the ends; the various spirals are wound so as to form two truncated cones in opposite direction to their base. This form of electro-magnet is especially made use of in Clark's instruments, to favor the effects of induction, which is more energetic in the center of the cores than at the extreme ends. Fig. 16 represents an electro-magnet with hollow cores and iron end pieces. Fig. 15 represents an electro-magnet with one coil. By bringing near together the two branches of such an electro-magnet, and bending the free branch around, as is shown in Fig. 17, we may bring the two poles of the electro-magnet very near together, and hence make them react at the same time on an armature placed endwise, and of very small size. A similar form, and devised for the same purpose, has been adopted by Mr. Hughes for the two bobbin electro-magnets of his telegraphs, the branches, however, being bent back, as in Fig. 22.

If a soft iron cylindrical case is placed around the bobbin and soldered to the circular end piece of a straight electro-magnet, this cylinder will share the magnetism of the end piece, and will present a like pole to its free end; hence there would be at one of the ends of the electro-magnet a circular pole, in the center of which the other pole would be found, as shown in Figs. 19 and 20. Manufacturers of these tubular electro-magnets claim a great superiority for them in strength over the other forms. Electro-magnets of this style have been used in electro-motors, the poles being oblong instead of circular, as shown in Figs. 26 and 27.

If we place over an iron tube electro-magnet like that shown in Fig. 8, two soft iron cylindrical cases, leaving between them, towards the middle of the electro-magnet, a small open groove, we shall obtain a circular electro-magnet having a different pole on each of the two iron cases which surround it, and hence acting through its two poles at the same time on a longitudinal or circular armature, on which it rests. This form of magnet, as shown in Figs. 21 and 34, has been proposed for magnetizing the wheels of locomotives on railroads, as an electro-transmitter of motion to supply gears.

By bending the yoke at right angles the two opposite poles of an electro-magnet may be made to face each other, as shown in Fig. 23; and by cutting the yoke in two, and sliding the two free parts in a groove made in a plate of soft iron, the distance of the poles from each other may be regulated at will. When it is desired that an armature should oscillate between the two poles of an electro-magnet, in which case magnetic armatures are usually employed, there are three ways that may be followed: the poles of the electro-magnet may be bent in such a way as to stand opposite to one another at any desired distance apart, or the two cores are brought sufficiently near each other to allow the oscillation to take place between them; or, lastly, the cores themselves are inclined at the proper angle to bring the poles near to each other. The latter method possesses a slight advantage over the others, in not requiring any marked lengthening of the cores, which is always detrimental; and at the same time it allows a direct attraction on the armature, which is more powerful than lateral attractions. Fig. 25 represents a magnet of this description.

Electro-magnets, with multiple poles, as shown in Fig. 24, are sometimes employed for large electro-motors. These magnets consist of an iron bar, carrying eight, ten, and twelve, or even more, iron cores, on which the magnetizing helices are placed; the even branches are all magnetized alike, or are of the same polarity, while the uneven are of the other. The result is that any one of these poles always stands between two poles, whose magnetism is opposite to that of the ones considered. Electro-magnets of this construction are very powerful, and consequently of considerable importance in the construction of electro-motors. Attempts have also been to magnetize iron plates in different ways. Fig. 28 shows one arrangement of this kind constructed by Joule, in which the plate is rolled into a cylindrical form, and the wire wound around it in the direction of the length of the cylinder.

By cutting a series of grooves in an iron plate, and introducing therein an insulated wire, bent back upon itself, as shown in Fig. 29, Mr. Pulvermacher has succeeded in making electro-magnets, with multiple poles, similar to those of Mr. Froment. With a single wire, however, these magnets are not very powerful; but, as they occupy but very little room, their number may be multiplied considerably. By making the grooves larger and the projection thicker, the wire may be turned back on itself several times, and the magnetic effect thereby be correspondingly increased. Figs. 48 and 49 represent in perspective and in section a magnet similar to the Siemens armature; it is, in fact, a very short and wide bar magnet, having enlarged ends. Fig. 50 represents a novel electro-magnet, devised by Prof. A. Rocci, in which the magnet is at the same time the conductor of the current. Around a stout iron wire is wound a piece of sheet iron so as to form a cylinder a couple of inches in thickness. To insulate the surfaces of the iron, a strip of oiled paper is wound up together with the iron. The poles of a battery being connected with the central wire and the external extremity of the sheet of iron, each layer of the latter converts the one next succeeding into an electro-magnet, which again exercises the same influence on the next one. The magnetic power increases toward the center, the greatest energy being displayed by the central wire.

When copper wire, insulated by a silk covering, is wound around the apparatus and an electric current passed through the same, the sheet of iron and the rod also become magnetic, but, in this case, the magnetic force decreases in energy toward the center, being weakest in the iron wire. When the electric current is passed through both the copper wire, the sheet iron and rod, the magnetic force becomes equally strong throughout the whole apparatus.

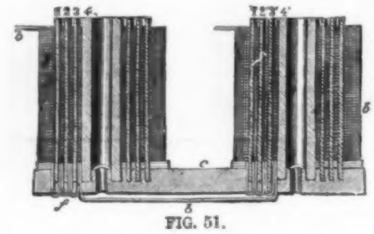


FIG. 51.

In the Camacho electro-magnet, shown in Fig. 51, each core is constituted by a series of concentric iron tubes 1, 2, 3, 4; 1′, 2′, 3′, 4′, leaving an interval between each equal to their thickness; on each of these tubes is coiled, always in the same direction, an insulated copper wire, *b*, the thickness of the wire layer being greater on the external tube. The extremities, *f*, of the wire corresponding to each tube cross the breech of the magnet, and are united in such a way as to form a single conductor.

By employing the current of the ten Bunsen elements, of ordinary dimensions, the attractive force of an electro-magnet like the one above described (bobbin fifteen centimeters in diameter and seventeen centimeters in length), at a distance of one millimeter, is of one thousand kilogrammes, and at six millimeters of two hundred and fifty kilogrammes.

With an ordinary telegraphic electro-magnet of fifty kilometers of resistance, compared to another like one, but of the system above described, the result in contact was the following:

| | | |
|---|---|---|
| Ordinary electro-magnet, | 4 kilogrammes | Leclanché 8 |
| Tubular " " | 20 " | elements. |

It should, finally, be stated that it was demonstrated by experiment that, if we cover the polar extremities of the tubes which constitute each core of these electro-magnets, by means of a round iron shield, the electro-magnet loses its great power, and is in the same conditions of an ordinary electro-magnet.

### ARRANGEMENT OF ARMATURES.

The armature of an electro-magnet, whether consisting of a temporary or permanent magnet, or simply of a soft iron bar, may be arranged in various ways relative to the electro-magnet, which acts upon it. It may be hinged to the two bobbins of the electro-magnet, or other suitable fixture in their neighborhood, as in Fig. 39, in which case its movement is effected parallel to the axial line of the electro-magnet; and, consequently, the attraction of the two poles on the iron is equal at both ends. It may be articulated by one end, as in Fig. 40, *bis*, in which case the movement takes place in an angular manner with respect to the axial line; and hence the action of the two poles on the iron is unequal, but, nevertheless, very efficacious, as one of the poles acts nearly in contact; or, it may be supported by a vibratory spring, as shown in figure 41; and, lastly, it may be articulated between the poles of the electro-magnet by means of a pivot parallel to the branches of the latter, as in Fig. 42. The movement then partakes of a tilting motion, and the attraction is effected in a lateral direction. This arrangement of armatures, however, applies only to the direct action of electro-magnets, which may be either normal or lateral. When we desire to employ the force of the latter on their armatures, through their reciprocal magnetic reactions, the arrangement of the armatures may be modified in three different ways.

They may be fixed flatwise, with regard to the poles of the electro-magnet, to the end of a lever, whose opposite end is hinged near the yoke of the electro-magnet, and whose motion is, consequently, in a direction at right angles to the line joining the poles. The armature, being then placed about one twenty-fifth of an inch above the polar ends of the electro-magnet, is carried over the poles by the magnetic action of the latter until its center coincides with the axial line of the magnet. This is, as remarked elsewhere, one of the best means of obtaining a large excursion of the armature; but, when the magnet is somewhat powerful, there is some risk of bending the supports. Fig. 43 sufficiently indicates this arrangement. The second way of arranging armatures to obtain a similar magnetic reaction is to pivot them so as to tilt, as shown in Fig. 42, above the ends of the magnet, which is provided with soft iron pole pieces. Siemens employed this method, in 1848, for his dial telegraph.

The third arrangement consists in pivoting them in such a way as to allow of their turning between the poles of the electro-magnet, the edges of which have been hollowed out in order that the armature may turn freely through nearly half of a circumference, as in Fig. 44. This is evidently the best arrangement, as the normal attraction of the poles, which is not concerned in the angular displacement of the armature, is in this case exerted at the two extreme ends of the armature and in opposite directions. There is, consequently, no injurious results to be apprehended either to the pivoting or from any flexion of the armature or pieces that support it.

One advantage in employing electro-magnetic arrangements of this description, besides the greater armature excursions, is that with the armature at but a little distance from the poles of the electro-magnet, the direct magnetic action, which is always the strongest,* reacts from the first instant of the armature's movement, which is precisely opposite to what takes place in other systems of attraction, and hence it is that its advantages in many instances are so marked. Two methods of arranging the armatures, and allowing the use of bar electro-magnets in place of double branched magnets, are shown in Figs. 35 to 37. These were first employed in a couple of electro-motors exhibited in 1855. In one, the armature is bent twice at right angles to itself, so as to bring its extremities opposite the two poles of the electro-magnet; the piece which supports it stands perpendicular to the axis of the electro-magnet, and passing through the latter, may also carry another armature, as shown in Fig. 35. In the other arrangement, the electro-magnet is hollow, and the armature in this case, a straight bar of iron, is placed inside the iron cylinder, and the armature support passes through the electro-magnet; the action of the latter is manifest in one direction or another, according to the proximity of the armature to one or the other of the inner sides of the cylinder. Preferable forms, on account of the simplicity of the arrangement of the various parts, are shown in Figs. 36 and 37, in which an oblong shape is given to the electro-magnets.

Various other arrangements of electro-magnets with permanently magnetized armatures are also employed.

When magnetic armatures are to be acted upon by both attraction and repulsion, double electro-magnets should be employed. Fig. 45 shows a frequently used form and it presents the advantage of allowing the additional action of a third force, which may be gravity.

In this arrangement the armature is pivoted at its center, so as to vibrate between the poles of two electro-magnets, but it will, of course, be understood that a single double electro-magnet may be employed. Fig. 46 represents a form in which the electro-magnet itself is movable while the armature is fixed, but the arrangement is not a good one where rapidity of movement is desired. Fig. 47 shows still another combination, somewhat similar to that represented in Fig. 45, but in which the armature is of soft iron and rendered magnetic by the addition of a surrounding coil, instead of being permanently magnetic itself.

## MAGNETO-INDUCTION CURRENTS.

According to the recent researches of Count du Moncel, if an iron stem or core wound with a coil be shifted in the direction of its axis in front of a magnetic pole, a series of induced currents in the same direction will be produced, succeeding each other, whilst the movement lasts, that is from end to end of the stem; but this effect will not manifest itself without a special disposition of the coil upon a ring entirely developed by the coil, for, in this case, the two opposite parts of the ring are oppositely polarized under the influence of a single inducing pole, and as the coil is wound in a different direction in relation to the two resultants corresponding to the neutral lines, the induced currents produced would be equal and contrary. For this reason M. Gramme has been obliged to divide the helix of his ring into sections, and to connect them in circuit by a collector. M. du Moncel also remarks that the induced currents in the Gramme machines are made up (1) of those which result from the movement of the coils induced before the conductor; (2) by those which are determined by the interversions of polarity of the iron ring; but the effects are the same as if those helices displaced themselves upon a fixed ring, having determinals and constant polarities.

## A LIQUID CURRENT INTERRUPTER.

Mr. Sergius Kern sends us an account of a very interesting experiment by M. Slouginoff, which is likely to be fruitful in research. He takes the two electrodes of a battery, one of which is a thin, plain platinum plate placed horizontally, and the other is a platinum wire placed perpendicularly to the plate, and nearly in contact with it. A small quantity of water, acidulated with sulphuric acid, is next poured on to the plate. If a current from 8 to 12 elements passes through the apparatus, and the wire is made the cathode, a spot of light is observed on its point. When using 15 elements the light appears, even if the direction of the current is changed. During these phenomena the water is only slightly decomposed, and the needle of a galvanometer, if introduced into the circuit, is only slightly deflected. It was also remarked that the water under the wire is lowered, forming the shape of a cup. The bubbles of gas, arising from the decomposition of the water, in this case travel constantly round the wire, forming a very pretty figure 8. This is caused by the movements of the surface of the water, it being alternately repelled and attracted to the wire carrying the current. . . . In employing a current of 12 elements, and introducing into it Slouginoff's apparatus, a distinct sound is remarked. If the platinum plate is well polished, the water is repelled from the point of the wire equally in all directions, and some millimeters from it. The current is thereby interrupted, and the liquid advances to the wire; in this case the liquid will be again repulsed, and so on.—*Crooke's Monthly Journal of Science.*

## THE AURORA.

The following observations were made at Annanatook, on the west coast of Cumberland Gulf (lat. 68° 13′ 45″ N., long. 67° 18′ 39″ W.) by the American Howgate Arctic Expedition. The most brilliant auroras were seen in January and April. The colors observed were usually pale blue, sometimes very pale green, rarely straw yellow, and once only rose at the base. The light from the aurora was sufficient to guide the traveler in his path. It occasionally affected the ordinary compass needle, as on the 29th August, when the ship's compass could not be used while the auroral display lasted.—*North American Review.*

* Experience shows that the electro-magnet force of an electro-magnet is greater at the edges of the poles than at its center, a fact of which we can readily convince ourselves by suspending a piece of soft iron and exposing it normally over the polar centers. The iron will be drawn from the vertical toward the edges.

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